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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

Reports

A Proposed Radioactivity Concentration Guide for Shellfish

C. L. Weaver [1]

The recommendations of the International Commission on Radiological Protection (ICRP), the National Committee on Radiation Protection (NCRP), and the Federal Radiation Council (FRC), have been applied in deriving proposed guides for radioactivity in shellfish. FRC Report No. 1 presents basic exposure criteria, FRC Report No. 2 presents intake guides for strontium–89, strontium–90, iodine–131, and radium–226, and NCRP and ICRP provide data on the maximum permissible concentrations of radionuclides in water. The proposed guide was assembled by the National Center for Radiological Health in collaboration with the Water Supply and Sea Resources Program of the National Center for Urban and Industrial Health, Public Health Service.

Radioactive wastes entering the water environment constitute a potential hazard to humans through consumption of shellfish which have taken up the radioactive material from the water (1–4). Potential sources of such materials are the liquid waste discharges from nuclear power plants, users of radionoclides, and from nuclear-powered ships (*5*). Radioactive wastes from these sources may be discharged into shellfish waters at concentrations not exceeding the applicable standards (Title 10, Part 20, Table II, Appendix B, of the Code of Federal Regulations or comparable State regulations) (*6*). However, due to the accumulation of radionuclides in aquatic food chains, it is possible for certain radionuclides to be present in edible portions of shellfish in quantities sufficient to be of public health concern, even though the concentrations of the radionuclides in water are within permissible limits according to applicable standards. In particular, bivalves have the capacity to concentrate radionuclides to several orders of magnitude above the water concentration. This is due, in part to their use of plankton as a food source.

Concentration factors

Shellfish have the ability, alone or by means of their aquatic food sources, to concentrate certain stable elements and radionuclides far above the ambient concentration in a saline water environment. The term "concentration factor" is commonly used to describe this process quantitatively and is defined as the ratio of the equilibrium quantity of a specific nuclide per unit wet weight of shellfish tissue to the quantity of the specific nuclide per unit weight of water.

The value of these factors vary with shellfish species, rate of metabolism, rate of developmental growth and concentration of the stable isotope of the element of concern in the receiving water. In some cases, the value varies with the concentration of the elements in the same chemical group as the element of concern. Other possible factors such as variations in the specific capacity of aquatic species in a food chain to accumulate radionuclides from host food, lead to fluctuation. Since all of the metabolic factors are temperature dependent, the concentration factor for a particular body of water could vary seasonally.

[1] Mr. Weaver is chief, Environmental Surveillance and Control Program, NCRH, Washington, D.C.

Considerations in deriving the radiological guide

The radioactivity guide for shellfish is based on the reports and recommendations of the International Commission on Radiological Protection (ICRP), the National Committee on Radiation Protection (NCRP), and the Federal Radiation Council (FRC) (*7–9*). However, it is necessary to translate their recommendations into specific numerical guides for use in evaluating the public health aspects of radioactive waste disposal practices. NBS Handbook 69(*10*) includes recommendations for the maximum permissible concentration of radioactivity in water $(MPC)_w$, expressed as microcuries-per-cubic centimeter (μCi/cc), for occupational exposure based on a 168-hour week. The intent of these $(MPC)_w$ values is to limit the daily intake of radionuclides which are assumed present in the 2,200 ml volume of water and the food consumed each day by a "standard man." (The maximum permissible daily intake for an occupational worker can be calculated by multiplying the $(MPC)_w$ by 2,200 ml). However, the daily intake for occupational workers must be adjusted so that it applies to the average member of the general public. In this regard, the ICRP recommends that a factor of one-thirtieth be used. Table 1, column 3, gives the (MPC) values for selected radionuclides for members of the general public. Table 1, column 4, gives the maximum permissible intake for the selected radionuclides, in μCi/day, derived on the above basis. In the cases of strontium–90 and iodine–131, the values in column 4 are those recommended by the Federal Radiation Council for the average of an exposed population group.

Selection of NBS Handbook 69 as the basic reference is based on the following statement from the Public Health Service Drinking Water Standards (*11*).

> "In assessing the hazard of radionuclides for which limits have not been provided by the Federal Radiation Council, it is suggested that the values $(MPC)_w$ for the 168-hour week, in table 1, of the report of the International Commission on Radiological Protection (*9*) or the National Committee on Radiation Protection (*10*), adjusted by a factor appropriate for exposure of the general population (1/30), be used. When mixtures of radionuclides are present, the permissible concentration of any single nuclide must be reduced by an amount determined through applicable calculations in these reports."

Guide for radioactivity concentrations in shellfish

The recommended guide for radioactivity concentration in shellfish is based on an assumed consumption rate of 50 grams (wet weight) of shellfish per day. Cowser and Snyder (*12*) report an annual fish consumption

Table 1. Radioactivity concentration guide for shellfish

1	2	3	4	5
Selected radionuclide	Concentration factor [a]	Maximum permissible concentration $(MPC)_w$ [b] (μCi/cc)	Maximum permissible radioactivity intake (μCi/day)	Radiological guide for radioactivity in shellfish (assuming a 50 g day wet weight intake) [d] (μCi/g)
Cromium-51	1,000–100,000	6.67×10^{-4}	1.47	3×10^{-2}
Manganese-54	5,000– 50,000	3.33×10^{-5}	7.33×10^{-3}	1×10^{-2}
Cobalt-58	1,000– 10,000	3.33×10^{-5}	7.33×10^{-3}	1×10^{-3}
Iron-59	3,000– 20,000	2.00×10^{-5}	4.40×10^{-3}	9×10^{-4}
Colbalt-60	1,000– 10,000	1.67×10^{-5}	3.67×10^{-3}	7×10^{-4}
Copper-64	5,000– 50,000	1.00×10^{-4}	2.20×10^{-1}	4×10^{-3}
Zinc-65	1,000– 10,000	3.33×10^{-5}	7.33×10^{-2}	1×10^{-3} Total body
Strontium-90	1–10	[c]	$^{c}2.00\times10^{-4}$	4×10^{-6} Bone
Zirconium-95	1,000– 2,000	2.00×10^{-5}	4.40×10^{-3}	9×10^{-4}
Ruthenium-103	5,000– 50,000	2.67×10^{-5}	5.87×10^{-2}	1×10^{-3}
Ruthenium-106	5,000– 50,000	3.33×10^{-6}	7.33×10^{-3}	1×10^{-4}
Iodine-131	100– 10,000	[c]	$^{c}1.00\times10^{-4}$	2×10^{-6} Thyroid
Cerium-144	1,000– 10,000	3.33×10^{-6}	7.33×10^{-2}	1×10^{-4}

[a] These concentration factors were not used in deriving the guides but are presented as one of the considerations for selection of the radionuclides in the first column.
[b] $(MPC)_w$ for 168-hour week multiplied by a factor of 1/30 for exposure of the general population.
[c] Based on the recommendations of the Federal Radiation Council for an average of suitable samples of an exposed population group.
[d] The critical organ is the gastrointestinal tract except as indicated. The μCi/g values have been rounded to the nearest whole number. Radionuclide concentration in shellfish can be compared with this guide only if they are reported as μCi/g, wet weight.

rate of 37 lb. (approximately 50 g/day) by commercial fishermen. Use of 50 g/day in deriving the shellfish guides is conservative in that it assumes all of the 50 grams consumed are shellfish and that the diet of the general population is similar to the diet of the commercial fisherman. In deriving the values listed in column 5, table 1, it is further assumed that the total radioactivity intake, including drinking water, results from shellfish consumption.

The values given in the guide for radioactivity in shellfish (table 1, column 5) were derived so that the product of assumed shellfish intake (50 g/day, wet weight) times these values (column 5) are equal to the values shown for the maximum permissible daily radioactivity intake (column 4). Thus the values shown in column 4 divided by 50 g/day gives the guide for radioactivity in shellfish (column 5). These values may be adjusted to conform to a known shellfish consumption of greater or less than the 50 g/day used in deriving the guide. The manner in which this guide should be used will depend upon whether there exists significant sources of radionuclide ingestion other than shellfish. Where other sources exist these guide values must, of necessity, be lowered.

The application of this guide requires the examination of radioactivity in shellfish by radiological surveillance techniques such as found in references (*13*) and (*14*). The radionuclides of public health significance which may be found in shellfish include the following:

A. Fission products which include radioisotopes of zirconium, ruthenium, iodine, cerium, and strontium.
B. Activation products, which include radioisotopes of chromium, manganese, iron, cobalt, copper, and zinc.

Table 1 presents a list of selected controlling radionuclides and the recommended guide for radioactivity in shellfish for an assumed intake of 50 grams per day. If the concentration of any single nuclide in shellfish reaches the recommended guide value, the shellfish should not be released for public consumption until after a comprehensive evaluation of the dose to the exposed population from all environmental sources shows that the FRC's Radiation Protection Guides will not be exceeded.

Evaluation of total intake of radioactivity

Analysis of shellfish for radionuclide content will provide data on the concentration of specific nuclides. If more than a single radionuclide is present in the total diet or by inhalation in significant amounts, the evaluation of the sample in terms of this guide should be modified. Assuming the radionuclides are exclusively derived from shellfish and if radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C and if the applicable radiological guides for the radionuclides are as shown in table 1, column 5, then the concentration in the mixture shall be considered to be within the shellfish radioactivity guide as shown in the following relationship:

$$\frac{C_A}{\text{Guide A}}+\frac{C_B}{\text{Guide B}}+\frac{C_C}{\text{Guide C}}=<1$$

The application of this guide may be illustrated by the following example using typical concentrations of radioactivity found in shellfish:

Radionuclide	Concentration in pCi/g
Zirconium-95	0.1
Zinc-65	75.0
Ruthenium-106	1.0

The computation can then be made as follows:

$$\frac{0.1}{900}+\frac{75.0}{1000}+\frac{1.0}{100}=0.085$$

Since the computed value is less than one, the radioactivity of the sample is within the criteria established by this guide.

From the standpoint of public health, radionuclide levels in shellfish cannot be the only source of radionuclides considered. The basic approach specified by FRC is to limit total intake of radionuclides from *all* sources so that Radiation Protection Guides are not exceeded. Under circumstances in which the concentrations in shellfish remain well below the guidance values, there is no need for public health concern from this vector. If the concentrations approach or exceed the guides, the public health significance must be evaluated in the context of radionuclide intake from all sources so that the total exposure does not exceed the Radiation Protection Guides (*15–17*). Annual averaging

of the daily radioactivity intake via shellfish is appropriate.

Control of population exposure from radionuclides occurring in the environment is accomplished either by restriction of the entry of radionuclides into the environment or through measures designed to limit the radionuclide intake from various vectors by members of the population. Both situations involve the consideration of actual or potential concentrations of radioactivity in air, water and food including shellfish. Controls should be based upon an evaluation of population exposure with respect to the radiological guides.

Acknowledgement

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Radioactivity in the Mexican Environment

R. M. Nulman and M. Vasquez Barete[1]

The Comisión Nacional de Energía Nuclear in Mexico operates surveillance networks monitoring radioactivity in airborne particulates, particulates in fallout and precipitation, drinking water, milk, food, and sea water. Methods of analysis and the resultant data for 1965 and 1966 are presented. This surveillance program was instituted to provide a general picture of the radioactivity levels in the Mexican environment, protection for the Mexican people from overdoses of radiation, and information for the handling of legal claims that may arise against the Nuclear Center of Mexico (now under construction).

As part of its program of radiological surveillance, the Comisión Nacional de Energía Nuclear (CNEN) in Mexico monitors the environment of the Mexican Republic with emphasis on the site of the Nuclear Center of Mexico and its surroundings. The Nuclear Center, now under construction, will contain a one megawatt Triga Mark III research reactor and a 12 MeV tandem Van de Graff accelerator. The Center will also produce radioisotopes for domestic use and exportation (*1*).

In order to provide a general picture of the radioactivity levels in the Mexican environment, protection for the Mexican people from overdoses of radiation, and information for the handling of legal claims that may arise against the Nuclear Center, the Environmental Radioactivity Section (ERS) has developed a program to routinely survey the levels of radioactivity in Mexico and monitor the levels of environmental radioactivity at the nuclear reactor site (Nuclear Center) and its surroundings.

The CNEN operates surveillance networks monitoring radioactivity in airborne particulates, particulates in fallout and precipitation, drinking water, milk, food, and sea water. Radioactive particulates in air results are published monthly in *Radiological Health Data and Reports* (*2*) and are summarized for 1965 through 1966 in table 1. In addition, gross beta radioactivity in samples of airborne particulates taken in the vicinity of the Nuclear Center are given in table 1. When the average radioactivity at any station for the month is greater than or equal to 1 pCi/m^3, an analysis is made to determine the strontium–90, cesium–137 and potassium–40 content of a monthly composite sample from that station. In 1965 a special study was conducted on the radiochemical separation techniques using samples containing less than 1 pCi/m^3 of gross beta radioactivity. Results of these radiochemical separations for 1965 through 1966 are presented in tables 2 to 4.

Rainwater is collected in a 1-gallon polyethylene bottle using a funnel with an opening of known area. Each month, or when the bottle is ¾ full, the funnel is rinsed with a known quantity of distilled water and the sample is forwarded to the ERS laboratory in Mexico, D.F., for analysis.

Analysis begins with the filtering a 1-liter aliquot of the sample through a Millipore filter. Dissolved solids are determined by evaporating the filtrate to a small volume, transferring it to a planchet, evaporating it to dryness, and counting in a beta-particle, anti-coincidence counter. Suspended solids are determined by

[1] Mrs. Vasquez Barete is director and Mrs. Nulman is a physicist, Comisión Nacional de Energía Nuclear, México, D.F.

Table 1. Gross beta radioactivity of airborne particulates, Mexico, 1965–1966

Station	Average gross beta radioactivity (pCi/m³)											
	1965											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Acapulco	0.1	0.1	0.1	0.1	NS	0.2	<0.1	<0.1	<0.1	<0.1	NS	<0.1
Chihuahua	.2	.1	.1	.2	0.8	.9	.1	< .1	< .1	.1	0.1	< .1
Ciudad Juárez	.2	.2	.2	.2	.1	.2	.1	< .1	.1	.1	.1	.1
Ensenada	.2	.1	.2	.2	.2	.2	.1	< .1	.1	.1	.1	< .1
Guadalajara	.1	.1	.1	.1	.3	< .1	< .1	< .1	< .1	< .1	< .1	.2
Guaymas	.1	NS	.1	.2	.4	.2	< .1	< .1	< .1	.1	< .1	< .1
La Paz	.3	NS	.3	.3	.2	.2	.2	< .1	< .1	.1	< .1	< .1
Matamoros	< .1	< .1	NS	.1	.2	.2	.1	< .1	NS	< .1	NS	NS
Mazatlán	NS	NS	NS	NS	NS	.3	.1	< .1	< .1	.1	< .1	< .1
Mérida	.1	.1	.1	.1	.2	.1	< .1	< .1	< .1	< .1	< .1	< .1
México, D.F.	< .1	.1	.1	.2	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
Nuevo Laredo	< .1	< .1	NS	.2	NS	.2	.1	< .1	< .1	NS	< .1	< .1
San Luis Potosí	.1	.1	< .1	< .1	.3	.3	< .1	< .1	< .1	< .1	< .1	< .1
Tampico	.2	.2	.1	.2	.1	.1	< .1	< .1	< .1	< .1	< .1	< .1
Torreón	.2	.2	.2	.1	.3	.3	.1	< .1	< .1	.1	< .1	< .1
Veracruz	.1	.1	NS	NS	NS	.2	< .1	< .1	< .1	< .1	.1	< .1
	1966											
Acapulco	NS	0.3	NS	0.1	NS	NS	0.1	0.1	<0.1	0.1	0.1	0.1
Chihuahua	0.7	.6	0.3	.2	1.0	3.0	.4	.1	< .1	.1	.1	.1
Ciudad Juárez	.6	.7	.3	.2	.5	.6	.3	.1	< .1	.1	.1	.1
Ensenada	.4	NS	.2	NS	.2	NS	.2	.1	.1	.1	.1	.1
Guadalajara	NS	.3	.2	NS	.2	NS	.1	.1	< .1	.1	NS	NS
Guaymas	.4	.5	.3	NS	.3	.6	NS	.4	< .1	NS	NS	NS
La Paz	.2	.2	.3	.2	.1	.4	.2	.1	< .1	.1	.1	.1
Matamoros	.3	NS	.3	.1	NS	NS	.2	.1	< .1	.1	NS	NS
Mazatlán	.2	.3	.3	.2	NS	.9	.2	.1	< .1	.1	.1	.1
Mérida	NS	NS	.3	.2	.8	.5	.3	.1	< .1	.1	.1	.1
México, D. F.	.3	NS	.3	NS	.1	.5	.3	.2	< .1	.1	.1	.1
Nuevo Laredo	.2	NS	.3	.2	.2	.6	.3	.2	NS	.2	NS	.1
San Luis Potosí	.2	NS	.1	.2	.6	NS	.1	.1	< .1	< .1	NS	NS
Tampico	.1	NS	.1	.1	.4	.8	.1	.1	< .1	< .1	.2	NS
Torreón	.2	.2	.3	.2	.5	.7	.3	.2	< .1	.2	.1	.1
Veracruz	.2	.2	.3	.2	.5	.4	.4	.2	< .1	.1	.1	.1
Nuclear Center							.1	.1	< .1			

NS, no sample reported.

ashing the filter and counting in a low background beta-particle counter which is calibrated with a thallium–204 standard. Results for 1965 through 1966 are presented in table 5. No radiochemical separation is made unless the radioactivity is greater than 100 pCi/liter, which is one-tenth of the maximum permissible concentration of gross beta radioactivity in drinking water for the general population. When levels are high, radiochemical separations are made for strontium–90, cesium–137 and potassium–40.

Table 2. Strontium-90 particulates in air, Mexico

Station	Concentration (pCi/1,000 m³)			
	May 1965	June 1965	July 1965	June 1966
Acapulco	NS	NA	1.07 ±0.03	NS
Chihuahua	10.19 ±0.15	6.22 ±0.10	6.21 ±0.04	3.5 ±0.46
Ciudad Juárez	4.88 ±0.02	NA	3.36 ±0.06	NA
Ensenada	7.12 ±0.23	10.17 ±0.05	NA	NS
Guadalajara	11.97 ±0.15	NA	2.92 ±0.15	NS
Guaymas	5.79 ±0.2	9.22 ±1.2	0.12 ±0.02	NA
LaPaz	1.56 ±0.32	NA	4.30 ±0.04	NA
Matamoros	8.31 ±0.07	NA	NA	NS
Mazatlán	NS	12.44 ±0.11	2.37 ±0.03	1.65 ±0.03
Mérida	5.60 ±0.41	0.42 ±0.03	0.95 ±0.03	NA
México, D. F	10.38 ±0.45	7.06 ±0.21	1.55 ±0.03	NA
Nuevo Laredo	NS	3.73 ±0.04	2.08 ±0.03	NA
San Luis Potosí	1.01 ±0.02	2.82 ±0.03	2.59 ±0.02	NS
Tampico	3.43 ±0.03	6.20 ±0.05	0.13 ±0.05	NA
Torreón	4.44 ±0.03	3.35 ±0.26	6.06 ±0.11	NA
Veracruz	NS	6.13 ±0.13	3.81 ±0.07	NA

NS, no sample reported.
NA, no analysis performed.

Table 3. Cesium-137 particulates in air, Mexico

Station	Concentration (pCi/1,000 m³)				
	June 1965	July 1965	Aug 1965	Sept. 1965	June 1966
Acapulco	NA	NA	NA	NA	NS
Chihuahua	3.40 ±0.02	7.4 ±0.42	6.68 ±0.88	6.16 ±0.16	4.8 ±0.29
Cuidad Juárez	NA	NA	1.56 ±0.90	NA	NA
Ensenada	NA	NA	NA	NA	NS
Guadalajara	NA	NA	NA	NA	NS
Guaymas	NA	NA	NA	NA	NA
LaPaz	NA	NA	NA	NA	NA
Matamoros	NA	NA	NA	NS	NS
Mazatlán	NA	NA	NA	NA	6.0 ±0.30
Mérida	NA	7.10 ±0.60	NA	NA	NA
México, D. F	NA	NA	NA	NA	NA
Nuevo Laredo	NA	NA	NA	NA	NA
San Luis Potosí	NA	6.02 ±0.26	NA	NA	NS
Tampico	5.71 ±0.79	6.08 ±0.20	NA	NA	NA
Torreón	NA	NA	1.50 ±0.27	NA	NA
Veracruz	NA	NA	NA	NA	NA

NS, no sample reported:
NA, no analysis performed.

Table 4. Potassium-40 particulates in air, Mexico

Station	Concentration (pCi/1,000 m³)			
	May 1965	June 1965	July 1965	June 1966
Acapulco	NS	NA	1.49	NS
Chihuahua	1.12	0.88	1.12	1.13
Ciudad Juárez	2.16	NA	2.11	NA
Ensenada	2.23	1.40	NA	NS
Guadalajara	0.93	NA	1.72	NS
Guaymas	1.95	1.24	2.48	NA
LaPaz	0.19	NA	1.53	NA
Matamoros	1.61	NA	NA	NS
Mazatlán	NS	0.56	1.60	0.29
Mérida	1.24	1.60	1.18	NA
México, D. F	2.23	1.12	3.72	NA
Nuevo Laredo	NS	2.61	2.79	NA
San Luis Potosí	1.59	1.35	1.72	NA
Tampico	1.12	1.45	1.32	NA
Torreón	1.31	1.86	1.17	NA
Veracruz	NS	0.93	1.59	NA

NS, no sample reported.
NA, no analysis performed.

Drinking water is sampled weekly in Mexico City and monthly from areas around the Nuclear Center. The monthly sample, or a monthly composite of the weekly samples, is analyzed for gross beta radioactivity on dissolved and suspended solids by the same procedure used for rainwater (*4*). Radiochemical analyses are made for strontium–90, cesium–137 and potassium–40 only if the gross beta radioactivity in the composite is greater than one-tenth of the maximum permissible concentration of gross beta radioactivity in drinking water for the general population. The results for 1966 are presented in table 6. Rivers and lakes in the vicinity of the Nuclear Center are sampled and analyzed by the same method used for drinking water. The results are given in table 7.

Monthly composites of liquid milk samples collected weekly from five sampling locations in Mexico and four zones around Mexico City are analyzed for strontium-90. Two monthly powdered milk samples are also analyzed. The radiochemical procedure is based on the separation of the alkaline earth metals from milk on an ion exchange column. Then the strontium is extracted using techniques of differential solubility and liquid extraction with di-2-ethylhexyl-phosphoric acid (DEHP) in toluene.

Table 5. Gross beta radioactivity in rainwater, Mexico, 1965–1966

Station	Concentrations of gross beta radioactivity		1965					1966									
			Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Acapulco:	pCi/liter	SS [a]	------	------	<3	------	------	------	------	------	< 3	10.0	21.3	< 3	<3	<3	< 3	
		DS	------	------	<3	------	------	------	------	------	9.6	12.0	17.0	7.0	<3	<3	< 3	
	nCi/m³	SS	------	------	<0.1	------	------	------	------	------	< 0.1	0.4	2.8	0.1	<0.1	<0.1	0.2	
		DS	------	------	< .1	------	------	------	------	------	< .1	.5	2.3	.1	.4	<3	0.1	
Nuclear Center:	pCi/liter	SS	19.5	------	------	------	------	------	------	9.0	8.0	8.0	9.1	5.7	<3	<3	< 3	
		DS	6.6	------	------	------	------	------	------	9.5	5.3	24.4	14	< 3	<3	<3	< 3	
	nCi/m³	SS	0.9	------	------	------	------	------	------	0.4	.7	.3	0.6	.5	.8	.1	.1	
		DS	.3	------	------	------	------	------	------	.4	.5	1.1	< 1	.2	.2	.1	.3	
Chihuahua:	pCi/liter	SS	------	------	------	------	------	------	------	< 3	< 3	46.5	< 3	------	<3	<3		
		DS	------	------	------	------	------	------	------	9.1	< 3	30.0	3.6	------	<3	6.2		
	nCi/m³	SS	------	------	------	------	------	------	------	.1	.3	3.9	.3	------	.4	< .1		
		DS	------	------	------	------	------	------	------	.5	.2	2.7	.4	------	.8	.8		
México, D. F:	pCi/liter	SS	------	------	------	------	------	------	------	3.3	< 3	5.9	< 3	< 3	<3	<3		
		DS	------	------	------	------	------	------	------	< 3	< 3	.1	19.3	< 3	<3	<3		
	nCi/m³	SS	------	------	------	------	------	------	------	.1	.1	.4	.1	.4	.2	< .1		
		DS	------	------	------	------	------	------	------	.1	.1	.5	3.1	.2	.3	< .1		
San Luis Potosí:	pCi/liter	SS	------	------	------	------	------	------	------	------	28.5	8.6	------	< 3	<3	3.4		
		DS	------	------	------	------	------	------	------	------	15.4	38.4	------	< 3	<3	8.9		
	nCi/m³	SS	------	------	------	------	------	------	------	------	.6	.4	------	< .1	< .1	.2		
		DS	------	------	------	------	------	------	------	------	.3	1.7	------	< .1	< .1	.5		
Torreón:	pCi/liter	SS	------	61.6	------	------	20.5	------	------	19.4	17.7	26.3	50.7	23.2	4.7	3.2	13.7	<3
		DS	------	19.4	------	------	5.9	------	------	78.3	28.0	38.3	52.9	31.2	3.1	4.1	30.5	<3
	nCi/m³	SS	------	2.7	------	------	.9	------	------	2.0	.1	1.1	1.5	.3	.4	.1	.1	<0.1
		DS	------	0.8	------	------	0.3	------	------	.8	.5	1.7	1.6	.3	.3	.2	.3	< .1
Veracruz:	pCi/liter	SS	------	------	------	------	------	13.8										
		DS	------	------	------	------	------	3.8										
	nCi/m³	SS	------	------	------	------	------	.6										
		DS	------	------	------	------	------	0.2										

[a] SS, suspended solids.
DS, dissolved solids.

Table 6. Gross beta radioactivity in drinking water, Mexico, 1966

Station	Sample fraction	Average concentrations (pCi/liter)										
		Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Colonia Ortiz Rubio	SS	.....	.....	<3	3.4	<3	.....	< 3	<3	<3	.....	.....
	DS	.....	.....	<3	4.4	<3	.....	< 3	<3	<3	<3	<3
Huixquilucan	SS	< 3	.....	.....	5.5	5.0	.....	< 3	<3	<3	.....	<3
	DS	10.0	.....	.....	< 3	<3	.....	< 3	5.2	<3	.....	<3
Lerma de Villada	SS	.....	.....	.....	.....	.....	.....	< 3	.....	<3	<3	.....
	DS	.....	.....	.....	.....	.....	9.3	< 3	.....	4.6	<3	.....
Salazar	SS	.....	5.2	.....	< 3	.....	.....	.....	.....	.....	.....	.....
	DS	.....	<3	.....	< 3	.....	.....	.....	.....	.....	.....	.....
San Miquel Ameyalco	SS	.....	.....	.....	.....	.....	< 3	< 3	<3	<3	<3	<3
	DS	.....	.....	.....	.....	.....	3.5	5.1	<3	<3	<3	<3
Cuajimalpa	SS	.....	.....	4.0	.....	.....	.....	.....	<3	.....	<3	<3
	DS	.....	.....	<3	.....	.....	.....	.....	<3	.....	<3	<3
Joquicingo	SS	.....	<3	.....	.....	.....	.....	.....	.....	.....	.....	.....
	DS	.....	3.2	.....	.....	.....	.....	.....	.....	.....	.....	.....
San Ignacio Allende	SS	.....	.....	<3	16.6	3.2	< 3	.....	<3	6.0	.....	<3
	DS	.....	.....	<3	< 3	<3	< 3	.....	<3	<3	.....	<3
San Mateo Atarosquillo	SS	.....	.....	.....	15.1	3.6	.....	<3	<3	<3	<3	<3
	DS	.....	.....	.....	< 3	<3	.....	8.2	<3	<3	<3	<3
San Pedro Atlapulco	SS	.....	<3	<3	4.1	<3	.....	< 3	<3	<3	<3	.....
	DS	.....	<3	<3	8.1	<3	.....	< 3	<3	<3	<3	.....
San Jeronimo Acazulco	SS	.....	.....	<3	< 3	<3	< 3	.....	.....	.....	.....	.....
	DS	.....	.....	<3	< 3	3.7	10.2	.....	.....	.....	.....	.....
El Zarco	SS	.....	<3	.....	.....	<3	71.3	.....	.....	.....	.....	.....
	DS	.....	4.0	.....	.....	<3	< 3	.....	.....	.....	.....	.....
Ocoyoacac	SS	.....	3.4	<3	.....	<3	< 3	< 3	<3	.....	<3	<3
	DS	.....	7.3	5.3	.....	<3	< 3	< 3	<3	.....	<3	<3
México, D.F.	SS	.....	.....	.....	.....	1.8	< 3	< 3	<3	.....	.....	.....
	DS	.....	.....	.....	.....	1.9	4.2	10.1	<3	.....	.....	.....
Nuclear Center	SS	3.4	<3	<3	.....	.....	.....	< 3	<3	.....	.....	.....
	DS	5.6	<3	<3	.....	.....	.....	< 3	<3	.....	.....	.....

SS, suspended solids.
DS, dissolved solids.

Table 7. Gross beta radioactivity in rivers and lakes, Mexico, 1966

Station	Sample fraction	Average concentrations (pCi/liter)										
		1966										
		Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
River water:												
Salazar	SS	.....	5.2	.....	.....	.....	6.1	.....	3.0	.....	.....	<3
	DS	.....	3.0	.....	.....	.....	8.8	.....	3.0	.....	.....	<3
Huixquilucan	SS	.....	.....	.....	3.4	5.3	<3	4.6	<3	<3	.....	<3
	DS	.....	.....	.....	3.5	3.1	4.0	<3	7.9	<3	.....	<3
El Zarco	SS	.....	.....	4.6	.....	.....	.....	<3	<3	<3	<3	<3
	DS	.....	.....	<3	.....	.....	.....	<3	<3	<3	<3	<3
Ocoyoacac	SS	.....	< 3	3.6	.....	< 3	.....	.....	<3	.....	.....	.....
	DS	.....	< 3	4.6	.....	< 3	.....	.....	<3	.....	.....	.....
San Pedro Atlapulco	SS	.....	.....	5.0	<3	.....	.....	.....	.....	.....	.....	.....
	DS	.....	.....	<3	4.5	.....	.....	.....	.....	.....	.....	.....
San Jeronimo Acazulco	SS	.....	.....	.....	.....	3	.....	.....	<3	.....	.....	.....
	DS	.....	.....	.....	.....	13.3	.....	.....	3.7	.....	.....	.....
San Miguel Ameyalco	SS	.....	.....	.....	.....	.....	.....	5.0	.....	.....	.....	.....
	DS	.....	.....	.....	.....	.....	.....	6.8	.....	.....	.....	.....
Cuajimalpa	SS	.....	.....	.....	.....	.....	.....	.....	<3	.....	<3	<3
	DS	.....	.....	.....	.....	.....	.....	.....	<3	.....	<3	3.0
Joquicingo	SS	.....	.....	.....	.....	< 3	.....	.....	.....	.....	.....	.....
	DS	.....	.....	.....	.....	< 3	.....	.....	.....	.....	.....	.....
Río Lerma	SS	.....	10.6	.....	.....	.....	.....	.....	<3	<3	<3	.....
	DS	.....	11.6	.....	.....	.....	.....	.....	<3	<3	3.9	.....
Lake water:												
El Zarco	SS	4.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	DS	<3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Salazar	SS	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	<3
	DS	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	<3
Tamiahua	SS	.....	.....	7.8	.....	.....	.....	.....	.....	.....	.....	.....
	DS	.....	.....	NA	.....	.....	.....	.....	.....	.....	.....	.....

SS, suspended solids.
DS, dissolved solids.
NA, no analysis.

Table 8. Strontium-90 in Mexico milk, December 1965 and calendar year 1966

Station	Strontium-90 concentration	1965 Dec	1966 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Toluca	pCi/liter			<1		1.6±0.9	1.1±0.9	2.4±1.1	<1	2.1±0.7	<1		<1	1.1±0.5
	pCi/g Ca			<1		1.4± .8	<1	2.1±0.9	<1	1.8± .6	<1		<1	0.8± .4
Chalco	pCi/liter		1.2±0.6	<1	3.3±0.8	1.0± .5	8.0±2.7	<1	<1	<1	<1		<1	<1
	pCi/g Ca		0.9± .4	<1	2.5± .6	<1	6.3±2.1	<1	<1	<1	<1		<1	<1
Coapa	pCi/liter		3.1±1.1	1.0±0.9	7.5±2.4	<1	<1	<1		<1			<1	1.6± .1
	pCi/g Ca		2.3± .8	<1	6.7±2.2	<1	<1	<1		<1			<1	1.2± .5
Texcoco	pCi/liter		1.2± .4	1.0± .5	3.5±1.1	1.5± .5	2.3±1.1	<1	<1	<1			<1	1.7± .8
	pCi/g Ca		.9± .2	<1	2.9± .9	1.5± .5	1.4± .7	<1	<1	<1			<1	1.5± .7
Mérida	pCi/liter	<1		1.0± .6	5.0±1.7		1.0±1.0	2.3±1.2				<1		
	pCi/g Ca	<1		<1	3.8±1.3		<1	2.3±1.2				<1		
San Juan del Río	pCi/liter		2.6±1.1	1.9± .1	6.5±2.9	<1	3.9±1.3	1.9±1.9		2.8±1.3	<1		<1	1.9± .6
	pCi/g Ca		1.9± .8	1.6± .1	5.1±2.2	<1	3.2±1.1	1.5±1.2		2.5±1.2	<1		<1	1.4± .4
Veracruz	pCi/liter	1.6±0.5	1.5± .6	1.2±1.3	4.7±1.9	2.7±1.6	1.3± .8	<1	2.5±1.4	4.0±2.4	6.0±1.3	<1	4.9±1.1	<1
	pCi/g Ca	1.3± .4	1.5± .5	1.4±1.2	5.3±1.9	1.9± .8	1.2± .7	<1	2.1±1.1	3.9±1.7	4.8±1.0	<1	3.6±0.8	<1
Mexico, D.F	pCi/liter								2.1±0.9					2.4± .9
	pCi/g Ca								2.0± .9					2.4± .4
Ensenada	pCi/liter						<1			4.9±1.8			<1	
	pCi/g Ca						<1			4.5±1.6			<1	
Huixquilucan	pCi/liter											<1	1.5± .7	2.9± .8
	pCi/g Ca											<1	1.2± .6	3.6±1.0
Chihuahua	pCi/liter	1.5±1.1		2.3±2.2										
	pCi/g Ca	1.1± .8		1.9±1.8										
San Mateo Atarosquillo	pCi/liter												<1	<1
	pCi/g Ca												<1	<1
Lagos [a]	pCi/liter		1.6± .9		2.9±1.1		1.5± .5	3.3±1.3	5.0±1.2	2.5± .7	5.7±1.0	1.6±0.2	5.3± .9	
	pCi/g Ca		1.3± .7		2.3± .9		1.1± .3	2.6±1.1	2.3±0.9	1.6± .5	4.2±0.7	1.1± .1	4.3± .8	
Tamuin [a]	pCi/liter		3.9± .5		1.2± .8	<1		<1		2.3±1.7	1.9± .5			
	pCi/g Ca		2.5± .3		1.0± .6	<1		<1		1.6±1.2	1.5± .4			

[a] Powdered milk sampling station.

Yttrium–90 is allowed to ingrow and is then extracted with DEHP and the organic layer is stripped with 3 *N* nitric acid. The carrier-free yttrium–90 is counted in a low-background anticoincidence counter. The chemical yield of the procedure is determined by spectrophotometric analysis of the strontium carrier remaining in the aqueous phase after extraction of the yttrium-90 for counting. The minimum detectable concentration with ±50 percent error at the 95-percent confidence level is 1 pCi/liter(*5*). The results for 1966 are given in table 8.

Fresh fruits and vegetables are purchased in season from the Mexico City area and around the Nuclear Center. The edible portions are homogenized, ashed, and counted in a low-background beta-particle counter (*6*). Results are given in table 9.

Sea water samples are taken quarterly by the Secretaria de Marina from sites 5 kilometers

Table 9. Gross beta radioactivity in foods, Mexico

Food	Sampling location	Date	Gross radioactivity (pCi/kg)
Chili	México, D.F.	8/23/66	514 (moist base)
Fish	Tamiahua	6/10/66	4,910 (moist base)
	El Zarco	12/2/64	2,300 (moist base)
		1/18/65	2,207 (moist base)
		5/6/65	2,597 (moist base)
Pulque	El Zarco	11/18/65	2,795 (moist base)
	San Ignacio Allende	8/10/66	195 (moist base)
	San Miguel Ameyalco	1/26/66	6,000 (moist base)
	Las Cruces	10/14/65	3,572 (moist base)
	San Pedro Atlapulco	8/24/66	249 (moist base)
		9/28/66	1,048 (moist base)
	San Ignacio Allende	9/14/66	815 (moist base)
	San Mateo Atarasquillo	9/8/66	1,240 (moist base)
		10/5/66	521 (moist base)
	San Jeronimo Acazulco	12/8/66	5,630 (moist base)
	Joquicingo	2/2/66	3,875 (moist base)
		4/8/66	4,414 (moist base)
Shrimp	Topolobampo	2/16/66	1,180 (moist base)
	Tamiahua	6/10/66	6,678 (moist base)
Corn	San Ignacio Allende	1/18/65	2,352 (dry base)
	San Miguel Ameyalco	3/26/65	1,591 (dry base)
Oats	Salazar	9/28/65	3,092 (dry base)
Capulin (plum):			
branches	Ocoyacac	7/6/66	1,460 (dry base)
fruit		7/6/66	1,592 (dry base)
branches	San Mateo Atarasquillo	7/27/66	14,117 (dry base)
fruit		7/27/66	1,466 (dry base)
Onions	Ocoyoacac	8/24/66	5,750 (dry base)
	San Pedro Atlapulco	12/28/66	5,518 (dry base)
Milk	Huixquilucan	3/16/66	103,000 (dry base)
Horse beans	Ocoyoacac	5/20/65	482 (dry base)
		5/26/66	35,973 (dry base)
	San Ignacio Allende	7/1/65	2,201 (dry base)
		4/8/65	23,123 (dry base)
		5/6/66	195 (dry base)
	San Pedro Atlapulco	5/14/65	12,713 (dry base)
	San Miguel Ameyalco	9/29/65	53,553 (dry base)
	Mirasol	11/2/66	7,577 (dry base)

Table 10. Radiochemical analysis of sea water, Mexico

Station	Date	Beta radioactivity in insoluble sulphides (pCi/liter)	Beta radioactivity in insoluble carbonates (pCi/liter)	Beta radioactivity in soluble carbonates (pCi/liter)	Beta radioactivity in suspended solids (pCi/liter)	Gross beta radioactivity (pCi/liter)	Strontium-90 (pCi/liter)	Iodine-131 (pCi/liter)	Potassium-40 (pCi/liter)	Cesium-137 (pCi/liter)	Strontium-90 (pCi/g Ca)
Acapulco	March 1966	6.0	10.3	421.6	----------	421.6	0.6	0.4	404	0.3	2.6
	September 1966	7.5	14.0	480.4	----------	480.4	1.0	.6	457	.3	2.9
	October 1966	12.80±0.23	29.40±0.41	198.0±0.51	1.30	241.50					
Bahia de Todos Santos	March 1966	4.0	7.1	390.87	----------	390.87	1.5	.8	377	.4	4.9
	October 1966	5.20±0.30	10.34±0.38	243.2±0.43	2.23±0.20	260.97					
La Paz	October 1966	1.91±0.16	3.9±0.18	155.5±0.9							
Veracruz	September 1965	5.3	9.0	272.0	----------	272.0	.8	.6	256	.3	2.1
	September 1966	3.8	7.3	383.0	----------	383.0	.9	.7	370	.4	2.4
	October 1966	0.93±0.28	3.28±0.34	200.1±0.51	0.07±0.28	204.38					

from shore near 10 ports on the Pacific Ocean and the Gulf of Mexico. Methods of analysis are those outlined by Porter, *et al.* (*7*). Samples containing gross beta radioactivities greater than one-tenth of the maximum permissible concentration for drinking water are analyzed for strontium–90 and cesium–137. The results for 1966 are given in table 10.

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Data

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Both Federal and State agencies are involved in efforts to continuously monitor the intake of radionuclides from the diet. The most direct measure of radionuclide intake would be through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternative method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, milk is the single food item most often used in estimating the intake of selected radionuclides by the general and/or population groups. In the absence of specific dietary information, one may assume the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission of Radiological Protection (*5, 6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, recent *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	January–June 1966	March 1967

1. Pasteurized Milk Network
May 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent descrip-

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	<100	10	100 or greater	10
Barium-140	<100	10	100 or greater	10
Cesium-137	<100	10	100 or greater	10
Strontium-89	< 50	5	50 or greater	10
Strontium-90	< 20	2	20 or greater	10

[a] Two standard deviations.

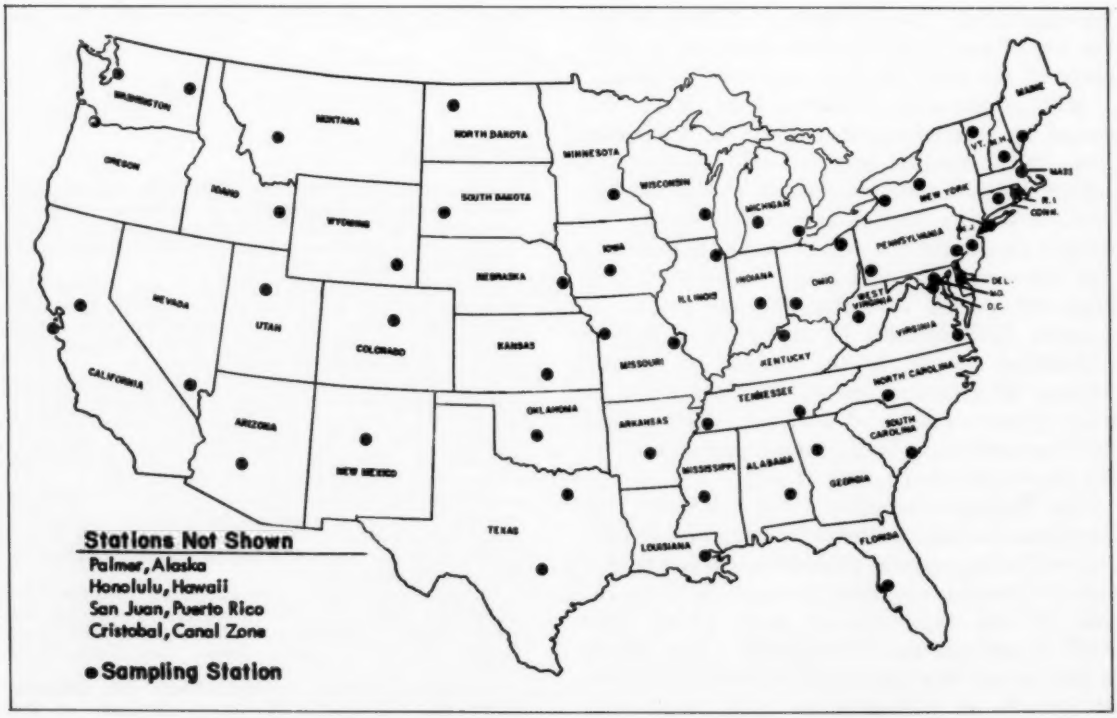

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentration of radionuclides in pasteurized milk for the first quarter 1967 and May 1967

Sampling location		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)	
		First quarter 1967	May [a] 1967	First quarter 1967	May 1967	First quarter 1967	May 1967	First quarter 1967	May 1967
Ala:	Montgomery	<5	< 5	12	10	10	0	15	20
Alaska:	Palmer	<5	< 5	9	7	0	0	20	20
Ariz:	Phoenix	<5	< 5	2	1	0	0	< 5	< 5
Ark:	Little Rock	<5	< 5	23	29	0	0	20	20
Calif:	Sacramento	<5	10	3	4	0	0	< 5	15
	San Francisco	<5	5	4	6	0	0	< 5	5
C. Z:	Cristobal	<5	< 5	6	5	0	0	25	35
Colo:	Denver	<5	< 5	6	5	0	0	< 5	10
Conn:	Hartford			10	9	0	0	25	25
Del:	Wilmington			11	13	0	0	20	20
D. C:	Washington	<5	< 5	10	10	0	0	15	15
Fla:	Tampa	<5	< 5	9	9	0	0	70	80
Ga:	Atlanta	<5	< 5	17	17	10	0	25	25
Hawaii:	Honolulu	<5	< 5	5	4	0	0	15	10
Idaho	Idaho Falls	<5	< 5	7	7	0	0	10	15
Ill:	Chicago	<5	< 5	9	10	0	0	20	15
Ind:	Indianapolis	<5		10	10	0	0	20	10
Iowa:	Des Moines	<5	5	9	10	0	0	10	15
Kans:	Wichita	<5	10	9	8	0	0	5	10
Ky:	Louisville	<5	< 5	14	14	0	0	15	15
La:	New Orleans	<5	< 5	27	27	0	0	35	30
Maine:	Portland	<5		13	12	0	0	45	40
Md:	Baltimore	<5	< 5	11	13	0	0	20	15
Mass:	Boston	<5	< 5	13	12	0	0	35	35
Mich:	Detroit			10	9	0	0	20	20
	Grand Rapids	<5		11	11	0	0	25	25
Min:	Minneapolis	<5	5	14	12	0	0	15	20
Miss:	Jackson	<5	< 5	21	21	10	0	20	20
Mo:	Kansas	<5	10	10	9	0	0	5	10
	St. Louis	<5	10	11	10	0	0	10	10
Mont:	Helena	<5	< 5	7	6	0	0	10	15
Nebr:	Omaha	<5	< 5	10	8	0	0	10	10
Nev:	Las Vegas	<5	< 5	3	1	0	0	< 5	5
N. H:	Manchester	<5		16	15	0	0	45	50
N. J:	Trenton	<5		10	10	0	0	25	20
N. Mex:	Albuquerque	<5	< 5	5	3	0	0	< 5	10
N. Y:	Buffalo	<5		9	9	0	0	20	20
	New York City	<5		11	13	0	0	20	25
	Syracuse	<5		9	10	0	0	20	20
N. C:	Charlotte	<5	< 5	18	19	0	0	20	15
N. Dak:	Minot	<5	10	17	19	0	0	15	30
Ohio:	Cincinnati	<5		11	12	0	0	20	15
	Cleveland	<5		12	11	0	0	20	25
Okla:	Oklahoma City	<5	< 5	10	12	0	0	10	15
Ore:	Portland	5	< 5	8	9	0	0	10	15
Pa:	Philadelphia	<5		11	9	0	0	20	20
	Pittsburgh			13	15	0	0	25	30
P. R:	San Juan	<5	< 5	5	4	0	0	15	15
R. I:	Providence	<5		11	11	0	0	30	30
S. C:	Charleston	<5	< 5	18	15	20	0	30	40
S. Dak:	Rapid City	<5	10	11	13	0	0	15	15
Tenn:	Chattanooga	<5	< 5	16	17	0	0	20	15
	Memphis	<5	< 5	13	16	0	0	10	10
Tex:	Austin	<5	< 5	4	4	20	0	10	10
	Dallas	<5	< 5	9	11	10	0	10	10
Utah:	Salt Lake City	<5	< 5	7	6	0	0	10	15
Vt:	Burlington	<5		11	11	0	0	25	25
Va:	Norfolk	<5	< 5	12	14	0	0	15	15
Wash:	Seattle	<5	5	11	14	0	0	25	40
	Spokane	<5	< 5	11	12	0	0	20	20
W. Va:	Charleston	<5	< 5	12	17	0	0	15	15
Wisc:	Milwaukee			8	7	0	0	20	20
Wyo:	Laramie	<5	< 5	7	4	0	0	10	10
Network average		<5	< 5	10.7	10.8	0	0	20	20

[a] Blank indicates no strontium-89 determinations were made on samples from station during month.

tion of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (*1*).

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The results for May 1967 and first quarter of 1967 are presented in table 2. The average monthly radionuclide concentra-

tions are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable values; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 3 and 4 for May 1966 and December 1966 through May 1967. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, strontium-90 concentrations in milk at PMN stations, May 1966, December 1966–May 1967

Strontium-90 (pCi/liter)	Number of stations						
	1966		1967				
	May	Dec	Jan	Feb	Mar	Apr	May
Under 10	10	23	24	21	25	25	25
10–19	38	35	36	38	35	34	35
20–29	12	5	3	4	2	4	3
30–39	3	0	0	0	1	0	0

Table 4. Frequency distribution, cesium-137 concentrations in milk at PMN stations, May 1966, December 1966–May 1967

Cesium-137 (pCi/liter)	Number of stations						
	1966		1967				
	May	Dec	Jan	Feb	Mar	Apr	May
Under 50	51	62	62	62	62	62	61
50–99	11	1	1	1	1	1	2
100–149	1	0	0	0	0	0	0

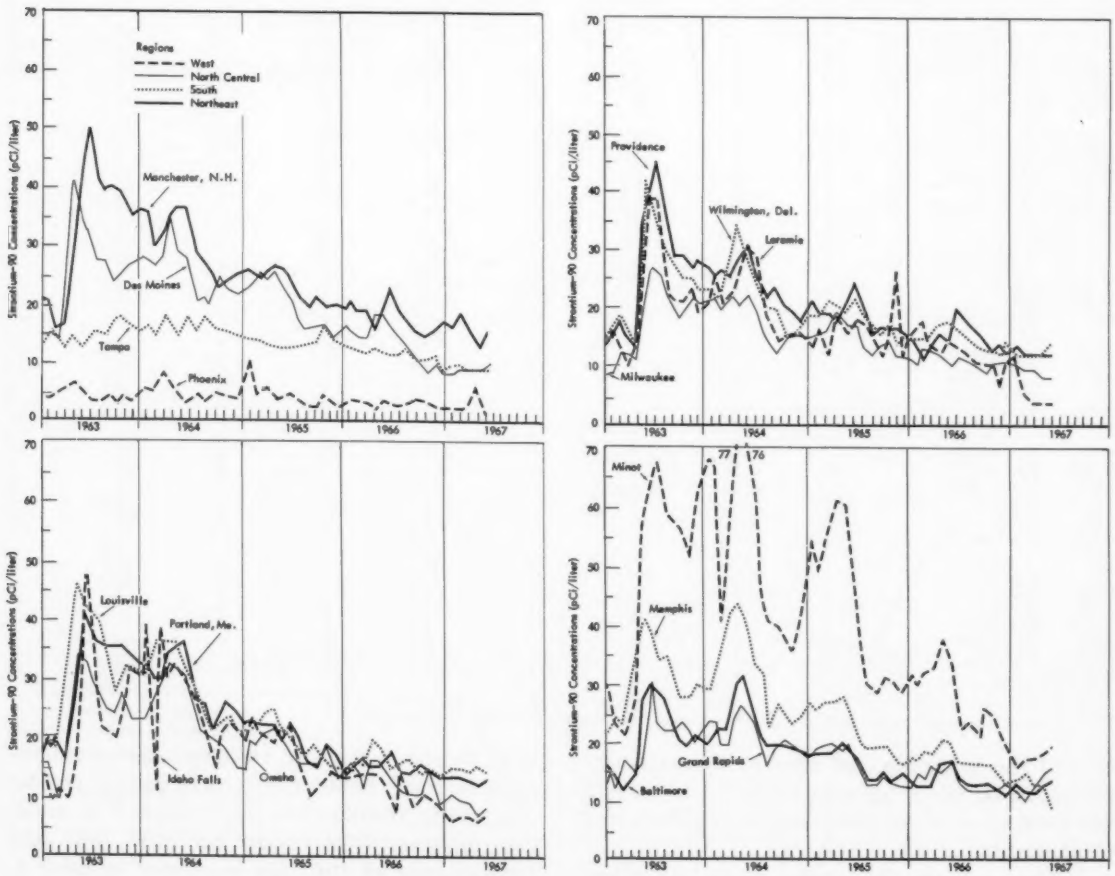

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961–May 1967

2. Canadian Milk Network May 1967[1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (*2*).

The May 1967 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from June 1967 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 5. Stable element and radionuclides in Canadian whole milk, May 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.08	NS	12	NS
Edmonton	1.10	1.4	13	39
Ft. William	1.10	1.5	15	44
Fredericton	1.11	1.5	21	53
Halifax	1.11	1.5	15	43
Montreal	1.08	1.4	13	29
Ottawa	1.13	1.4	12	30
Quebec	1.07	1.4	18	57
Regina	1.07	1.4	14	37
St. John's, Nfld	1.10	1.4	20	61
Saskatoon	1.09	1.5	13	29
Sault Ste. Marie	1.11	1.4	21	51
Toronto	1.14	1.5	7	26
Vancouver	1.16	1.5	22	72
Windsor	1.13	1.6	7	22
Winnipeg	1.18	1.7	14	42
Average	1.11	1.5	15	42

NS, no sample collected.

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program May 1967

Pan American Health Organization and
U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

Table 6 presents stable potassium, strontium–90, and cesium–137 monthly average concentrations for May 1967.

Table 6. Stable element and radionuclide concentration in PAHO milk, May 1967 [a]

Sampling stations	Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:				
Santiago	1	1.66	2	15
Colombia:				
Bogota	1	1.47	2	10
Ecuador:				
Guayaquil	1	1.60	<1	<5
Jamaica:				
Kingston	NS			
Mandeville	1	1.42	8	80
Montego Bay	NS			
Venezuela:				
Caracas	NS			
Canal Zone:				
Cristobal [b]	4	----------	5	35
Puerto Rico:				
San Juan [b]	4	----------	4	15

[a] Iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples. Strontium-89 was less than 5 pCi/liter for all samples.
[b] For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone and San Juan, Puerto Rico, from the Pasteurized Milk Network, are presented.
NS, no sample collected.

Figure 4. Pan American Milk Sampling Program locations

4. Radiostrontium in milk July–December 1966[2]

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring strontium–90 in liquid whole milk in New York to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, N.Y. (1954), and at Mandan, N. Dak. (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959. Sampling was terminated at Mandan, N. Dak., and Honolulu, Hawaii at the end of June 1965.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Perry samples are monthly composites of powdered whole milk for human consumption collected weekly in 5-pound lots from plants in the city. The strontium–90 to calcium ratios in whole milk are presented in table 7.

[2] Data summarized from "Fallout Program Quarterly Report," HASL–182, available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 7. Strontium-90/calcium ratios in milk July–December 1966

Sampling location	Strontium-90/calcium ratio (pCi ^{90}Sr/g Ca)					
	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y. (liquid whole milk)	12.4	13.6	13.2	7.4	9.0	7.2
Perry, N.Y. (powdered whole milk)	13.4	13.6	12.2			

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	June 1966
January–June 1966	March 1967

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1966. Radiol Health Data Rep 7: 698–701 (December 1966).
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(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows those States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in the current issue are highlighted in the figure. A summary of State programs previously covered, the reporting period, and issue of appearance are as follows:

State milk network	Period covered	Last presented
Colorado	January–March 1967	July 1967
Connecticut	January–March 1967	August 1967
Florida	April–June 1966	October 1966
Indiana	January-March 1967	August 1967
Iowa	January–March 1967	August 1967
Michigan	January–March 1967	August 1967
Minnesota	January–March 1967	August 1967
New York	January–March 1967	August 1967
Oklahoma	January–March 1967	July 1967
Pennsylvania	January–March 1967	August 1967
Tennessee	January–March 1967	July 1967
Texas	January–March 1967	July 1967

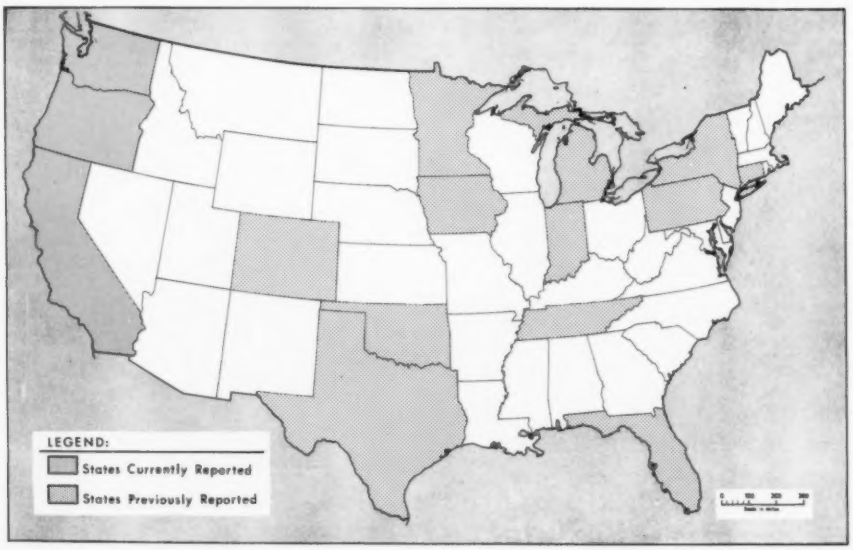

Figure 1. State milk programs reported

1. California Milk Network January–March 1967

Division of Environmental Sanitation
State of California, Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Public Health program on radiation control. This milk monitoring function is conducted by the Department's Bureau of Radiological Health at 10 major milksheds (figure 2).

In January 1960, the eight original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. The Del Norte and Mendocino milksheds were added to the program in March 1962 and since that time, weekly, biweekly or monthly sampling of pasteurized milk has been conducted in 10 milkshed areas of the State. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically. Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented in an earlier report (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period of January to March 1967.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 3.

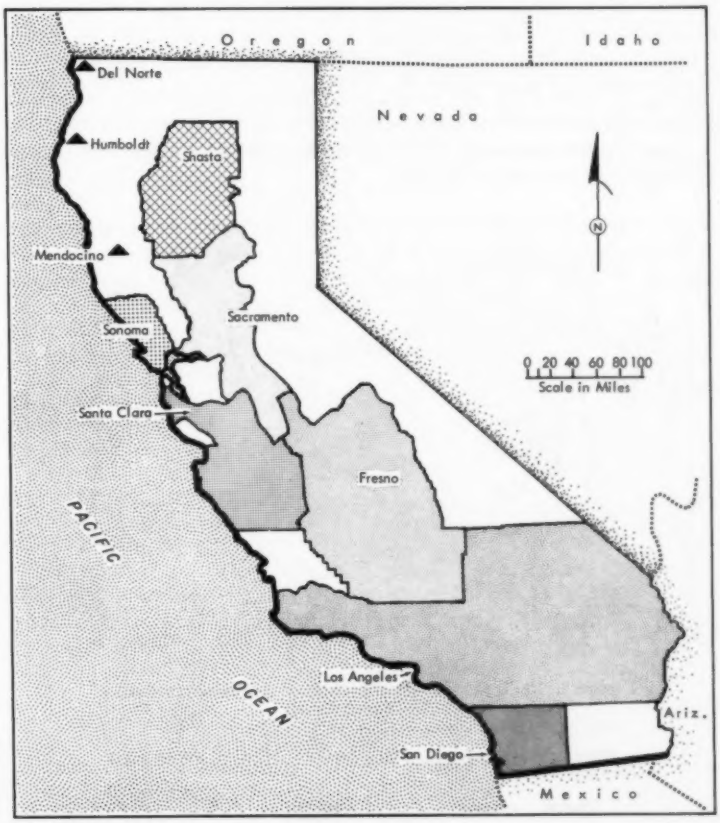

Figure 2. California milksheds

Table 1. Stable element and radionuclides in California milk, January-March 1967

Sampling location	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average [b]
Calcium (g/liter)											
January	1.32	1.27	1.21	1.14	1.16	1.24	1.13	1.17	1.18	1.17	1.20
February	NS	1.22	1.21	1.12	1.20	1.21	1.18	1.13	1.19	1.20	1.18
March	1.30	1.23	1.24	1.13	1.19	1.20	1.14	1.12	1.18	1.16	1.19
Potassium-40 (pCi/liter)											
January	1,080	1,205	1,130	1,215	1,290	1,260	1,235	1,180	1,170	1,260	1,203
February	NS	1,210	1,185	1,230	1,280	1,160	1,260	1,205	1,175	1,290	1,222
March	1,050	1,090	1,125	1,250	1,160	1,185	1,265	1,230	1,115	1,155	1,163
Strontium-89 (pCi/liter)											
January	22	ND	12	ND	1	[a]1	[a]1	[a]1	[a]1	ND	6
February	NS	ND	3	ND	ND	ND	ND	ND	ND	[a]2	3
March	27	ND	8	ND	8	[a]1	ND	[a]2	[a]2	4	7
Strontium-90 (pCi/liter)											
January	23	4	7	2	3	3	1	2	5	4	5
February	NS	4	6	3	3	4	3	2	4	4	4
March	14	2	6	2	7	3	2	4	3	4	5
Iodine-131 (pCi/liter)											
Januray	[a]29	[a]5	20	4	[a]4	17	[a]8	[a]12	16	[a]9	12
February	NS	[a]6	13	14	[a]5	12	5	[a]9	[a]7	[a]7	9
March	40	13	16	11	9	12	[a]2	[a]8	[a]7	10	13
Cesium-137 (pCi/liter)											
January	73	24	59	7	[a]8	[a]17	[a]9	[a]18	[a]14	[a]12	24
February	NS	[a]5	ND	[a]3	ND	ND	[a]3	[a]2	[a]6	ND	4
March	ND	ND	ND	ND	[a]5	ND	ND	[a]3	ND	ND	4
Barium-140 (pCi/liter)											
January	43	[a]1	33	[a]15	[a]11	[a]24	12	[a]12	32	[a]18	20
February	NS	[a]10	[a]5	13	[a]13	20	[a]9	[a]12	[a]55	[a]6	16
March	25	30	20	[a]16	[a]10	[a]6	[a]4	[a]8	19	ND	15

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

[b] Estimate of average if 10 percent or more of values averaged are not statistically significant.

NS, no sample collected

ND, non-detectable.

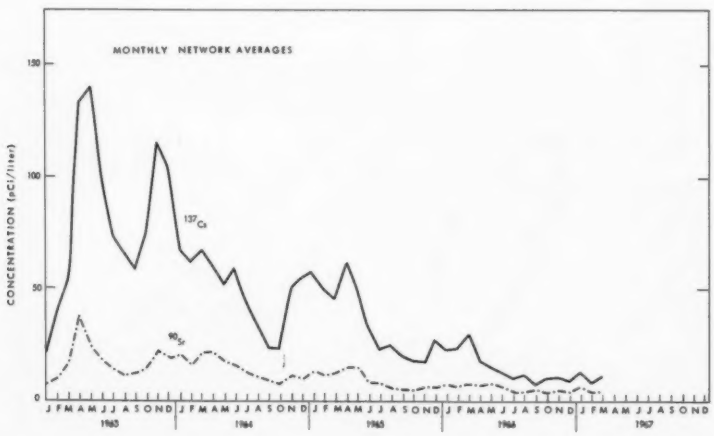
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
150
100
50
0
137Cs
90Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1963
1964
1965
1966
1967

Figure 3. Radionuclide concentrations in California milk, 1963–March 1967

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1966	March 1967
October–December 1966	June 1967

2. Oregon Milk Network January–March 1967

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at seven major production areas (figure 4), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine–131 concentrations exceed 100 pCi/liter, or where cesium–137 concentrations exceed 500 pCi/liter. Strontium–90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium–90 concentrations are determined using a trichloracetic-acid analytical procedure (*3*). Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 2. Radionuclide concentrations in Oregon pasteurized milk, January–March 1967

Location	Sampling frequency[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90			Cesium-137		
		January	February	March	January	February	March
Baker	M	8	NA	7	<15	<15	<15
Coos Bay	M	15	NA	14	41	16	58
Eugene	M	12	NA	12	65	22	31
Medford	M	6	NA	8	30	19	20
Portland composite	W	15	NA	10	32	21	19
Portland local	W	17	NA	16	23	33	27
Redmond	M	7	NA	5	18	30	32
Tillamook	M	16	NA	22	37	35	18
Average	--	12	------	12	32	24	27

[a] M, sampled monthly.
W, sampled weekly.
NA, no analysis.

Table 2 gives the strontium–90 and cesium–137 concentrations in pasteurized milk from January through March 1967. These data are presented graphically in figure 5. Iodine–131 and barium–140 concentrations remained below minimum detectable levels of 15 pCi/liter except for nine samples which were collected in January following the December 27, 1966, Chinese nuclear test (table 3). The Redmond sample, obtained on January 3, 1967, contained

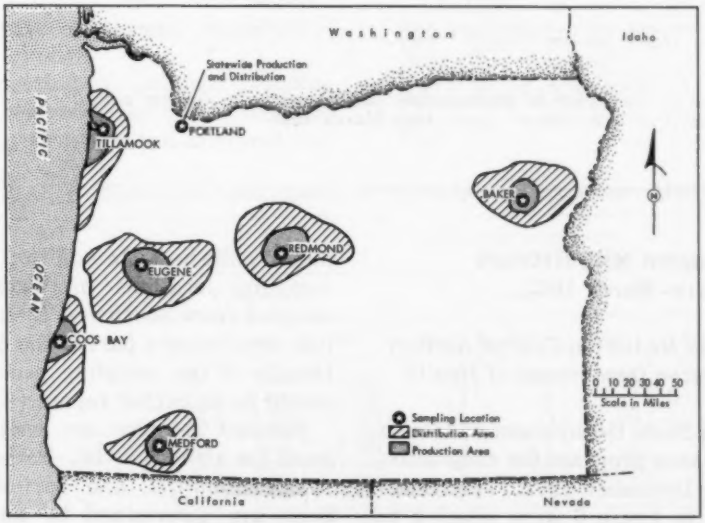

Figure 4. Oregon milk production and distribution areas

115 pCi/liter of iodine–131, the Portland composite sample which was collected on January 6 had 70 pCi/liter of iodine–131 and the Brookings sample, obtained on January 24, contained 25 pCi/liter of barium–140.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1966	March 1967
October–December 1966	June 1967

Table 3. Concentrations of iodine-131 and barium-140 in Oregon milk samples, January 1967

Location	Collection date (January 1967)	Iodine-131 (pCi/liter)	Barium-140 (pCi/liter)
Portland composite	6	70	<15
Tillamook	9	40	<15
Coos Bay	3	40	<15
	16	24	<15
Eugene	2	20	20
Redmond	3	115	18
	6	20	<15
Baker	8	20	<15
Brookings	24	< 15	25

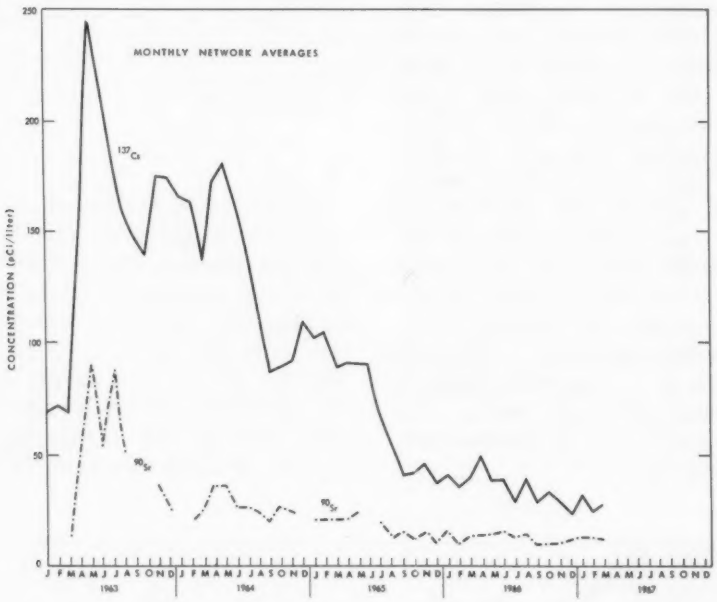
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
250
200
150
100
50
0
137Cs
90Sr
90Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1963
1964
1965
1966
1967

Figure 5. Radionuclide concentrations in Oregon milk, 1963–March 1967

3. Washington Milk Network January–March 1967

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 6 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented in an earlier report (*5*).

Selected samples are radiochemically analyzed for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

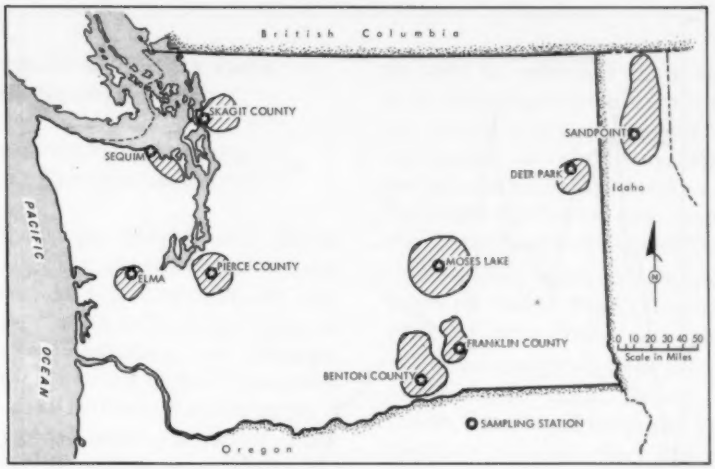

Figure 6. Washington milksheds and sampling locations

Table 4 presents monthly radionuclide concentrations in Washington raw milk for January through March 1967. Seven samples collected between January 3 and 10 showed iodine–131 levels ranging between 11 and 19 pCi/liter as a result of the December 27, 1966, Chinese nuclear detonation. Samples collected during the previous and subsequent months contained less than 10 pCi/liter of iodine–131. Barium–140 results remained below 15 pCi/liter for all samples collected during this period. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 7 to display general trends.

During this reporting period, four samples were collected (three from Benton County and one from Franklin County) and analyzed for zinc–65. In all four cases, zinc–65 levels were less than 25 pCi/liter. Milk samples produced in areas using Columbia River water for irrigation have periodically been found to contain this radionuclide.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1966	March 1967
October–December 1966	June 1967

REFERENCES

(*1*) HESLEP, J. M. and A. C. CORNISH. California milk network and milkshed comparisons, April–June 1963. Radiol Health Data 4:596–599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960–June 1962. Radiol Health Data 4:90–92 (February 1963).

Table 4. Radionuclide concentrations in Washington raw milk, January-March 1967

Sampling location	Radionuclide concentration (pCi/liter)								
	Potassium-40			Strontium-90			Cesium-137		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Benton County	*1,180	NS	1,180	5	NS	5	*16	NS	<15
Deer Park	*1,200	1,220	1,140	8	9	8	*32	18	29
Elma	*1,200	1,210	1,270	7	7	5	*25	28	<15
Franklin County	NS	1,270	NS	NS	3	NS	NS	<15	NS
Moses Lake	*1,230	1,170	1,220	*6	5	5	*16	<15	<15
Pierce County	*1,200	1,310	1,280	7	8	10	*24	26	33
Sandpoint, Idaho	*1,210	1,190	1,140	23	23	25	*49	41	48
Sequim	*1,170	1,200	1,140	*8	4	9	*23	24	30
Skagit County	*1,210	1,150	1,190	13	10	11	*25	21	23
Average	1,200	1,215	1,195	10	9	10	26	22	24

* Represents an average of two or more samples collected at these sampling locations during the month.
NS, no sample collected.

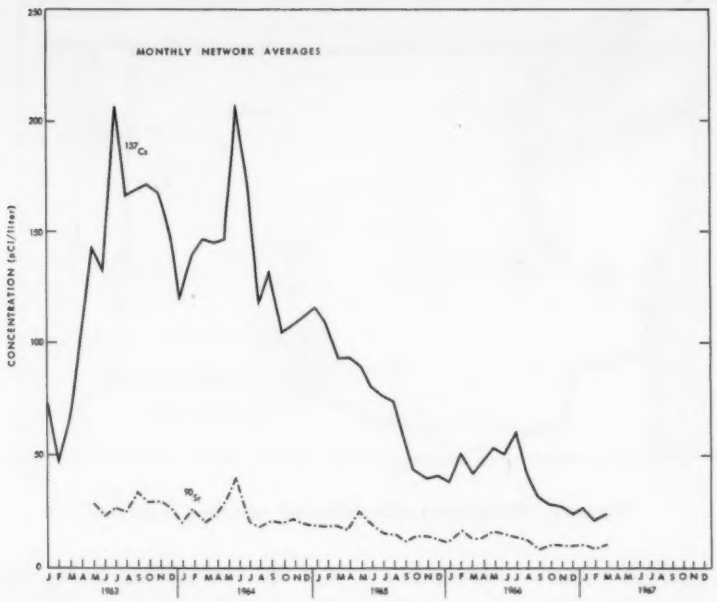
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
137Cs
90Sr
250
200
150
100
50
0
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1963
1964
1965
1966
1967

Figure 7. Radionuclide concentrations in Washington milk, 1963–March 1967

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy Sci 43:151–154 (1960).
(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April–June 1965. Radiol Health Data 6:683–684 (December 1965).
(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR SANITATION AND RADIATION CONTROL SECTION. Washington milk network, January–June 1965. Radiol Health Data 6:619–621 (November 1965).

Food and Diet Surveillance Activities

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	May–August 1966	May 1967
Connecticut Standard Diet	July–December 1966	May 1967
Institutional Diet, PHS	October–December 1966	July 1967
Teenage Diet, FDA	February–November 1965	August 1966
United Kingdom Diet	Annual summary 1965	December 1966

1. Strontium–90 in Tri-City Diets August–December 1966 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these 3 cities every 3 months on a staggered basis (*i.e.*, New York City, August 1966; San Francisco, September 1966; and Chicago, October 1966) and are analyzed for strontium–90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium–90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium–90 over the last 4 years has been approximately 5 percent. Therefore, this figure is used to calculate their contribution to the total strontium–90 dietary intake. These values are added to contributions of the other 14 food categories to obtain quarterly estimates of annual strontium–90 intake at the 3 cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and the average calcium content of foods was computed and used to estimate the

[1] Data from Fallout Program Quarterly Summary Report, HASL 182. Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, August–December 1966

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City August 1966		Chicago [b] October 1966		San Francisco September 1966		New York City [b] November 1966		San Francisco [b] December 1966	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Bakery products	37	37.0	14.6	540	6.8	252	6.5	241	6.6	244	3.9	144
Whole grain products	11	10.0	40.3	443	33.5	369	14.0	155	16.1	177	10.6	117
Fresh vegetables	43	15.0	17.6	757	8.1	348	2.0	86	9.9	426	6.4	275
Root vegetables	17	6.1	10.2	173	6.5	111	6.9	117	10.4	177	6.0	102
Milk	221	234.4	14.7	3,249	6.2	1,370	3.0	663	10.6	2,343	1.8	398
Flour	43	8.6	14.3	615	4.7	202	5.1	219	9.3	400	4.2	181
Macaroni	3	0.7	12.0	36	5.0	15	6.6	20	6.0	18	2.3	7
Rice	3	1.1	3.3	10	1.7	5	1.7	5	2.3	7	2.0	6
Dried beans	3	2.9	5.0	15	24.4	74	21.4	65	7.0	21	13.5	41
Fresh fruit	68	12.6	3.0	204	3.8	261	2.7	184	3.2	218	1.5	102
Potatoes	45	5.8	9.1	410	4.3	194	1.0	45	3.9	176	1.5	68
Canned fruit	26	1.3	1.8	47	1.2	31	1.4	36	2.9	75	1.2	31
Fruit juices	19	1.7	8.3	158	1.6	30	2.3	44	4.1	78	1.7	32
Canned vegetables	20	4.2	11.4	228	5.8	116	2.9	58	8.9	178	3.9	78
Meat, fish, poultry, shellfish, and eggs	99	42.0	----	[a] 362	----	[a] 178	----	[a] 102	----	[a] 239	----	[a] 183
Annual intake	----	383	----	7,247	----	3,556	----	2,040	----	4,777	----	1,665
Daily intake	----	1.05	----	19.9	----	9.7	----	5.6	----	13.1	----	4.6
pCi strontium-90/g Ca	----	----	----	19	----	9	----	5	----	13	----	4

[a] Estimated as 5 percent of total intake.
[b] Data based on analyses performed for HASL by a contractor laboratory and subject to revision.

average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the August to December 1966 samples are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1. A discussion of cesium–137 intakes as reflected in the Tri-City Diet Study has been presented previously (*4*).

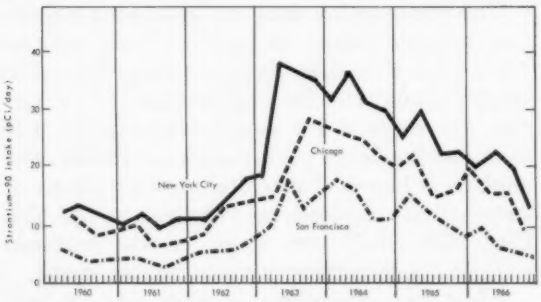

Figure 1. Daily intake of strontium–90 in Tri-City diet, March 1960–December 1966

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
November 1965–January 1966	September 1966
February–April 1966	December 1966
May–July 1966	June 1967

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1, 1955. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report, HASL–144:281–287. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (April 1, 1964). Summarized in Radiol Health Data 5:285–288 (June 1964).

(*3*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*4*) U.S. ATOMIC ENERGY COMMISSION, HEALTH AND SAFETY LABORATORY. Cesium–137 in Tri-City diets, 1965. Radiol Health Data Rep 8:154–157 (March 1967).

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the safe limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

Activity	Period reported	Last presented
California Water Sampling Program	January–June 1966	June 1967
Coast Guard Water Sampling Program	1965	November 1966
Minnesota Surface Water Sampling Program	January–June 1966	January 1967
New York Surface Water Sampling Program	June–December 1965	June 1966
Radiostrontium in Tap Water, HASL	March–November 1966	June 1967
Washington Surface Water Sampling Program	July 1965–June 1966	August 1967

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, March 1967

Division of Pollution Surveillance
Federal Water Pollution Control Adminstration
Department of Interior

The monitoring levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha- and beta-particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly

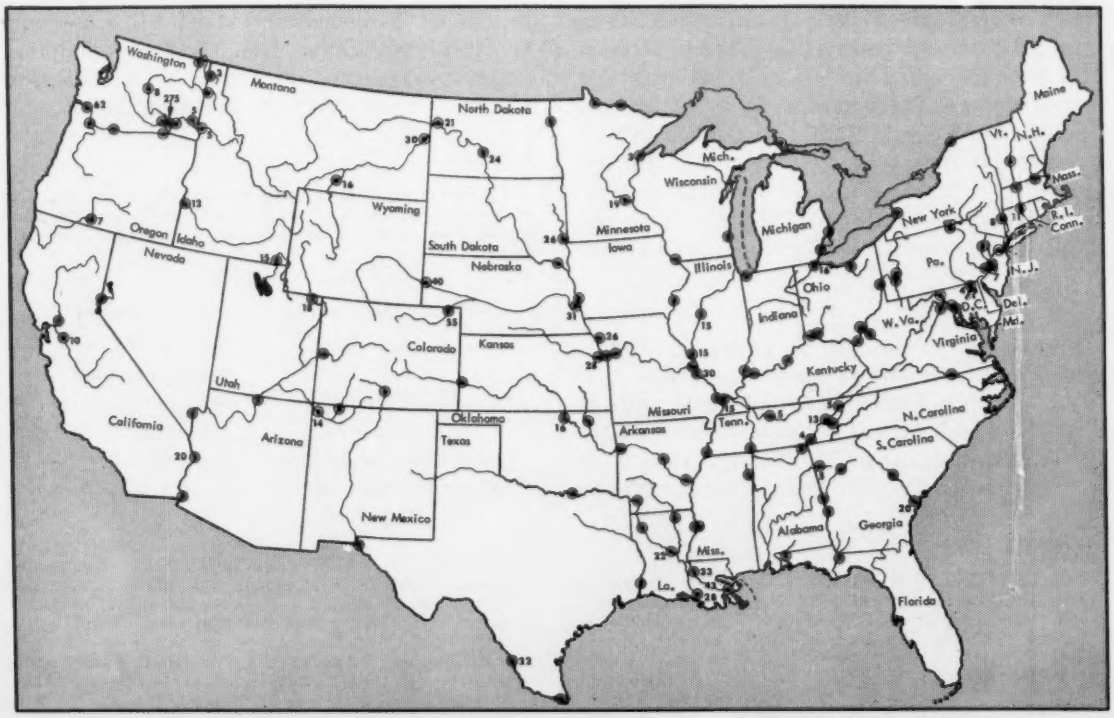

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) for surface waters, March 1967

Table 1. Radioactivity in raw surface waters, March 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	1	1	2	5	7	12
Arkansas River:						
Ponca City, Okla.	0	7	7	3	18	21
Atchafalaya River:						
Morgan City, La.	11	< 1	11	41	7	48
Bear River:						
Preston, Idaho	0	2	2	1	16	17
Big Horn River:						
Hardin, Mont.	0	10	10	3	23	26
Big Sioux River:						
Sioux Falls, S. Dak.	< 1	2	2	3	27	30
Clearwater River:						
Lewiston, Idaho	0	< 1	< 1	1	3	4
Clinch River:						
Clinton, Tenn.	2	0	2	8	3	11
Kingston, Tenn.*	0	0	0	0	16	16
Colorado River:						
Loma, Colo.	3	7	10	12	47	59
Page, Ariz.	0	5	5	1	29	30
Parker Dam, Calif.-Ariz.	0	9	9	0	19	19
Columbia River:						
Wenatchee, Wash.	0	0	0	0	4	4
Pasco, Wash.*	0	1	1	30	315	345
Clatskanie, Ore.	0	< 1	< 1	20	61	81
Connecticut River:						
Enfield Dam, Conn.	0	0	0	1	4	5
Coosa River:						
Rome, Ga.	< 1	1	1	2	3	5
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	1	3	4
Delaware River:						
Philadelphia, Pa.	1	0	1	3	7	10
Great Lakes:						
Duluth, Minn.	0	0	0	0	2	2
Detroit, Mich.	0	0	0	0	4	4
Green River:						
Dutch John, Utah	0	3	3	< 1	13	13
Hudson River:						
Poughkeepsie, N.Y.	0	0	0	1	6	7
Illinois River:						
Peoria, Ill.	1	2	3	4	10	14
Grafton, Ill.	0	3	3	2	11	13
Kansas River:						
DeSoto, Kans.	0	1	1	1	18	19
Klamath River:						
Keno, Ore.	< 1	0	< 1	2	7	9
Maumee River:						
Toledo, Ohio	0	1	1	5	7	12
Mississippi River:						
St. Paul, Minn.	0	1	1	1	11	12
E. St. Louis, Ill.	1	1	2	5	9	14
New Roads, La.	2	0	2	8	7	15
New Orleans, La.	3	1	4	7	7	14
Missouri River:						
Williston, N. Dak.	0	4	4	3	14	17
Bismarck, N. Dak.	1	3	4	8	14	22
St. Joseph, Mo.	2	4	6	7	17	24
North Platte River:						
Henry, Nebr.	0	27	27	2	34	36
Ohio River:						
Cairo, Ill.	3	0	3	22	6	28
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	1	1	1	4	5
Platte River:						
Plattsmouth, Nebr.	4	7	11	22	23	45
Potomac River:						
Washington, D.C.	1	0	1	1	3	4
Red River, North:						
Grand Forks, N. Dak.	0	0	0	0	19	19
Red River, South:						
Alexandria, La.	0	0	0	2	7	9
Rio Grande:						
El Paso, Tex.	51	2	53	205	16	221
Laredo, Tex.	1	8	9	4	14	18
San Joaquin River:						
Vernalis, Calif.	0	1	1	1	4	5
San Juan River:						
Shiprock, N. Mex.	4	2	6	13	8	21
Savannah River:						
Port Wentworth, Ga.*	0	0	0	2	12	14
Snake River:						
Payette, Idaho	0	4	4	1	13	14
Wawawai, Wash.	0	1	1	1	6	7
South Platte River:						
Julesburg, Colo.	2	30	32	11	45	56
Susquehanna River:						
Conowingo, Md.	0	0	0	0	5	5
Tennessee River:						
Chattanooga, Tenn.	< 1	1	1	2	5	7
Yellowstone River:						
Sidney, Mont.	4	7	11	22	15	37
Maximum	51	30	53	205	315	345
Minimum	0	0	0	0	2	2

* Gross beta radioactivity at this station may not be directl yeomparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both February and March 1967, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During March, both the alpha radioactivity and the beta radioactivity on suspended solids exceeded 15 pCi/liter and 150 pCi/liter, respectively, at El Paso, Tex., on the Rio Grande. Pasco, Wash., on the Columbia River continued to show beta radioactivity on dissolved solids in excess of 150 pCi/liter.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Radioactivity in New York Surface Water, January-December 1966

Division of General Engineering
and Radiological Health
State of New York Department of Health

In 1965, the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 45 locations for gross beta-particle analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger size samples are collected at selected locations for strontium–90 analysis.

Analytical procedures

Strontium and other alkaline earths are precipitated as carbonates from a 500 ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulfate from a pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (*1, 2*).

Strontium–90 is determined by yttrium–90 in-growth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas flow, proportional beta-particle counter. Strontium–89 is estimated by taking the difference between the total strontium and the strontium–90 radioactivity.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Discussion and results

The observed gross beta-particle concentrations in New York surface water for January–December 1966 are given in table 1. It should be noted that the Cohoes gross beta-particle results are for a raw water sample, while the Cohoes radiostrontium results are for a finished water sample.

The average concentrations of strontium–89 and strontium–90 in New York water for Jan-

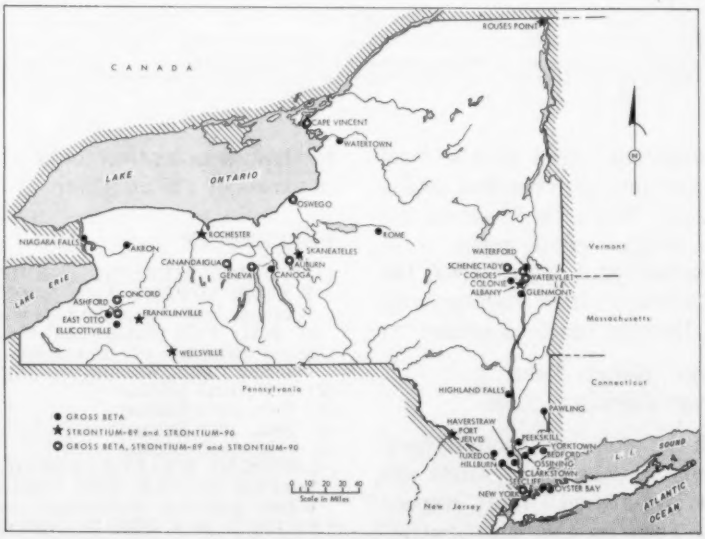

Figure 1. New York water sampling locations

Table 1. Gross beta radioactivity in New York raw surface water, January–December 1966

Location	Sampling	Concentration (pCi/liter)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Akron (Murder Creek)	BW	9	9	9	-----	6	6	6	5	3	6	6	7
Ashford (Buttermilk Creek at Fox Valley Bridge)	SA	1	2										
(Cattaraugus Creek at Bigelow Bridge)	SA	2	2										
(Buttermilk Creek at Thomas Corners)	SA	3	5										
(West Valley W.S. Reservoir)	SA	-----	6										
Auburn (Owasco Lake)	SA	-----	-----	-----	-----	-----	4	-----	-----	-----	3		
Bedford (Byram Lake)	M	-----	-----	7	-----	7	-----	-----	-----	-----	-----		
Canandaigua (Canandaigua Lake)	SA	5	-----	-----	-----	-----	6	-----	-----	-----	4		
Canoga (Cayuga Lake)	SA	-----	-----	-----	-----	-----	-----	-----	-----	-----	5		
Cape Vincent (Black River)	SA	5	-----	-----	-----	-----	-----	-----	-----	-----	-----		
(St. Lawrence River)	SA	-----	-----	-----	-----	-----	4	-----	-----	-----	-----		
Clarkstown (Congers Lake)	Q	-----	-----	-----	-----	-----	6	-----	10	-----	-----		
(Lake De Forest)	Q	-----	-----	-----	-----	-----	6	-----	5	-----	-----		
Cohoes (Mohawk River)	D	4	4	6	2	3	4	5	2	4	6	3	4
Colonie (Patroon Creek)	SA	-----	-----	-----	-----	-----	-----	10	-----	-----	-----	8	
Concord (18 Mile Creek)	SA	-----	3										
(Cattaraugus Creek at Scoby Hill Bridge)	SA	-----	4										
East Otto (East Otto Creek)	SA	-----	3										
(Connoisarauley Creek)	SA	-----	2										
Ellicottville (Beaver Meadow Creek)	SA	2	3										
Farmersville (Ischua Creek)	SA	3	3										
Geneva (Seneca Lake)	SA	-----	-----	-----	-----	4	-----	-----	-----	-----	3		
Glenmont (Hudson River)	D	3	6	6	3	3	4	5	5	4	3	4	6
Haverstraw (Letchworth Village River)	Q	-----	-----	-----	-----	2	3	-----	2	-----	2		
Highland Falls (Bog Meadow Brook)	M	2	-----	3	-----	3	4	4	2	4	-----	3	2
Hillburn (Hillburn Reservoir)	Q	-----	-----	-----	-----	8	2	-----	7	-----	< 1		
Lansing (Airport Well)	SA	-----	-----	-----	-----	-----	< 1						
(Kahrs Well)	SA	-----	-----	-----	-----	-----	< 1						
(Shively Well)	SA	-----	-----	-----	-----	-----	< 1						
(Tracey Tobey)	SA	-----	-----	-----	-----	-----	< 1						
(General Electric)	SA	-----	-----	-----	-----	-----	< 1						
(Buttermilk Creek)	SA	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4
New York City	SA	-----	-----	5									
Niagara Falls (East Branch-Niagara River)	Q	-----	-----	-----	-----	-----	-----	-----	4	-----	-----	5	
(West Branch-Niagara River)	Q	-----	-----	-----	-----	-----	-----	-----	3	4	-----	3	
Orangetown (Hackensack River)	SA	-----	-----	-----	-----	7	-----	-----	-----	-----	-----		
Ossining (Hudson River)	D	15	17	8	6	< 1	16	34	39	53	34	15	25
(Indian Brook Reservoir)	M	-----	< 1	5	-----	-----	4	6	6	5	-----	5	4
Oswego (Lake Ontario)	M	-----	-----	-----	-----	-----	-----	-----	-----	-----	6	5	
(Oswego River)	Q	-----	-----	-----	-----	4	6	-----	3	-----	6		
Oyster Bay (Lake Ontario)	SA	-----	4							5			
Pawling (Pond at United Nuclear)	M	-----	-----	-----	-----	-----	5	2	3	5	-----	4	
Peekskill (Camp Field Water Supply)	M	4	< 1	3	< 1	2	< 1	-----	< 1	7	14	3	5
(Hudson River)	D	12	6	3	10	4	17	24	29	36	18	16	15
Rome (Fish Creek)	BW	3	-----	-----	-----	-----	-----	-----	3	3	-----	4	3
Rouses Point (Lake Champlain)	Q	-----	-----	-----	-----	-----	-----	5					
Schenectady (Mohawk River)	C	4	4	5	-----	5	4	4	3	3	3	4	3
Tuxedo (Indian Kill)	M	3	-----	3	-----	-----	4	-----	3	4	-----	4	
Waterford (Hudson River)	C	3	3	5	-----	6	4	4	4	5	2	2	
Watertown (Black River)	BW	-----	5	4	4	5	4	4	4	4	4	4	4
Watervliet (French Mills Reservoir)	BW	4	4	4	-----	4	4	3	3	3	4	3	4
Yorktown (Croton Reservoir)	M	-----	-----	2	-----	-----	3	5	5	3	-----	4	4

BW, biweekly composite of daily grab samples.
D, weekly composite of daily grab samples.
C, continuous bleed-off-analyzed weekly.
NS, no sample collected.
M, monthly grab sample.
Q, quarterly grab sample.
SA, semiannual grab sample.

uary through November 7, 1966, were less than the level of detectability except for those stations listed in table 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	June 1966

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determinations of strontium–90 in milk by ion exchange method. Anal Chem 33:1306–1308 (September 1961).

(*2*) WELFORD, G. and D. SUTTON. A paper presented at the American Chemical Society meeting in New York City (September 1960).

Table 2. Strontium-89 and strontium-90 in New York surface waters, January-November 7, 1966 [a]

Location	Date 1966	Concentration (pCi/liter)	
		Strontium-89	Strontium-90
Ashford (Cattaraugus Creek at Bigelow Bridge)	3/15	8	< 3
Cohoes (Mohawk River)	1/10–17	11	< 3
Concord [b] (Springville Power Dam on Cattaraugus Creek	10/11–13	< 3	78
	10/14	69	174
	10/20–21	< 3	57
	10/27–28	65	265
	11/1–2	76	256
	11/2–3	73	234
	11/4–7	19	68

[a] All results for all stations, except for those listed, were below the detectable levels of 3 pCi/liter for strontium-89 and strontium-90.

[b] These samples were collected from a sampling station located downstream from the Nuclear Fuel Services spent fuel processing plant located in Cattaraugus County.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from programs of the U. S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data.* In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1965	March 1967
HASL 80th Meridian Network	Calendar Year 1965	January 1967
National Air Sampling Network (discontinued measurement)	October–December and annual summary 1966	April 1967
Plutonium in Airborne Particulates	October–December 1966	May 1967

1. Radiation Surveillance Network May 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators. These estimates are made after the decay of radon and thoron daughter products and prior to submission of the samples for laboratory analysis. When high airborne radioactivity levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during May 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

Gross beta radioactivity in air and precipitation continued to be near or below detectable levels. No indication of fresh fission products was found on any of the samples analyzed in May 1967.

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, May 1967

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	31	7	0.25	0.00	0.08	Nov 66	127	<25
Alaska:	Adak	31	----------	.11	.00	.03	June 67	[b]	
	Anchorage	21	2	.12	.01	.06	Dec 66	12	< 3
	Attu Island	31	----------	.05	.00	.01	July 67	[b]	
	Fairbanks	[c]	----------	----------	----------	----------	Jan 67	[b]	
	Juneau	16	10	.15	.00	.04	Apr 67	145	<29
	Kodiak	2	----------	.04	.02	.04	May 67	[b]	
	Nome	1	----------	.02	.02	.02	Sept 67	[b]	
	Pt. Barrow	30	----------	.14	.01	.04	Aug 67	[b]	
	St. Paul Island	[c]	----------	----------	----------	----------	Oct 66	[b]	
Ariz:	Phoenix	28	----------	.19	.05	.11	Apr 67	[b]	
Ark:	Little Rock	28	10	.11	.01	.06	Dec 66	317	<63
Calif:	Berkeley	24	----------	.17	.03	.09	May 67	[b]	
	Los Angeles	24	1	.12	.03	.07	Sept 67	2	< 1
C.Z:	Ancon	16	----------	.04	.01	.02	May 67	[b]	
Colo:	Denver	31	6	.13	.01	.06	May 67	74	<15
Conn:	Hartford	31	11	.20	.00	.07	Apr 67	99	<20
Del:	Dover	22	----------	.18	.03	.08	Nov 66	[b]	
D. C:	Washington	30	16	.18	.03	.07	Aug 67	97	<20
Fla:	Jacksonville	30	4	.18	.00	.08	Dec 66	41	< 8
	Miami	28	3	.21	.02	.08	Apr 67	29	< 6
Ga:	Atlanta	31	6	.22	.03	.09	Oct 66	82	<17
Guam:	Agana	30	----------	.04	.00	.01	Nov 66	[b]	
Hawaii:	Honolulu	31	2	.07	.01	.03	July 67	65	<13
Idaho:	Boise	30	4	.11	.02	.07	July 67	11	< 2
Ill:	Springfield	28	6	.17	.01	.08	Aug 67	135	<27
Ind:	Indianapolis	29	14	.16	.01	.08	Oct 66	139	<28
Iowa:	Iowa City	31	6	.14	.01	.09	May 67	25	< 5
Kans:	Topeka	31	3	.15	.01	.08	Dec 66	34	< 7
Ky:	Frankfort	27	8	.14	.02	.08	Aug 67	48	<10
La:	New Orleans	29	5	.20	.01	.08	Aug 67	64	<13
Maine:	Augusta	30	10	.12	.00	.05	Sept 67	116	<23
	Presque Isle	23	2	.33	.00	.04	May 67	11	< 2
Md:	Baltimore	22	7	.26	.03	.11	Apr 67	53	<11
	Rockville	15	----------	.16	.04	.08	July 67	[b]	
Mass:	Lawrence	30	9	.14	.01	.07	Nov 66	160	<32
	Winchester	19	8	.13	.01	.07	June 67	103	<21
Mich:	Lansing	30	10	.14	.00	.08	July 67	26	< 5
Minn:	Minneapolis	19	4	.09	.03	.07	Nov 66	30	< 6
Miss:	Jackson	28	7	.13	.01	.06	Sept 67	205	<41
Mo:	Jefferson City	31	12	.14	.01	.06	Oct 66	129	<26
Mont:	Helena	29	7	.16	.01	.08	June 67	43	< 9
Nebr:	Lincoln	19	6	.12	.01	.06	Oct 66	100	<20
Nev:	Las Vegas	25	----------	.17	.03	.08	Jan 67	[b]	
N. H:	Concord	21	----------	.18	.01	.08	Aug 67	[b]	
N. J:	Trenton	31	6	.14	.01	.07	Sept 67	18	< 4
N. Mex:	Santa Fe	29	2	.14	.02	.05	June 67	6	< 1
N. Y:	Albany	22	6	.18	.00	.08	Oct 66	69	<14
	Buffalo	24	----------	.12	.03	.07	May 67	[b]	
	New York City	30	----------	.15	.02	.07	June 67	[b]	
N. C:	Gastonia	31	11	.22	.02	.09	May 67	135	<27
N. Dak:	Bismarck	30	3	.13	.03	.07	Aug 67	22	< 5
Ohio:	Cincinnati	20	----------	.18	.03	.09	Nov 66	[b]	
	Columbus	28	11	.21	.04	.10	Sept 67	129	<26
	Painesville	29	12	.15	.03	.09	Apr 67	90	<18
Okla:	Oklahoma City	31	6	.20	.01	.08	July 67	89	<18
	Ponca City	26	5	.09	.00	.03	Apr 67	46	< 9
Ore:	Portland	31	7	.11	.01	.03	Oct 66	33	< 7
Pa:	Harrisburg	30	2	.13	.02	.06	Oct 66	81	<16
P.R:	San Juan	26	6	.20	.01	.07	Sept 67	80	<16
R. I:	Providence	30	10	.14	.00	.06	July 67	183	<37
S. C:	Columbia	24	10	.18	.01	.07	June 67	162	<33
S. Dak:	Pierre	31	3	.13	.01	.08	Apr 67	30	< 6
Tenn:	Nashville	31	10	.13	.01	.06	July 67	147	<29
Tex:	Austin	30	6	.14	.02	.06	Nov 66	68	<14
	El Paso	31	1	.22	.01	.09	Aug 67	2	< 1
Utah:	Salt Lake City	30	13	.18	.02	.10	Sept 67	55	<11
Vt:	Barre	30	15	.17	.01	.07	Dec 66	127	<26
Va:	Richmond	29	9	.17	.01	.08	Dec 66	57	<12
Wash:	Seattle	31	6	.09	.01	.05	Dec 66	12	< 3
	Spokane	31	4	.12	.01	.07	Nov 66	39	< 8
W. Va:	Charleston	29	17	.18	.01	.07	June 67	154	<31
Wis:	Madison	31	9	.26	.02	.07	Dec 66	102	<21
Wyo:	Cheyenne	31	13	.13	.01	.06	Jan 67	108	<21
Network summary		1,930	409	0.33	0.00	0.05	----------	82	<16

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 are reported and used in averaging as 0.00 pCi/m³.
[b] No precipitation sample collected.
[c] No report received.

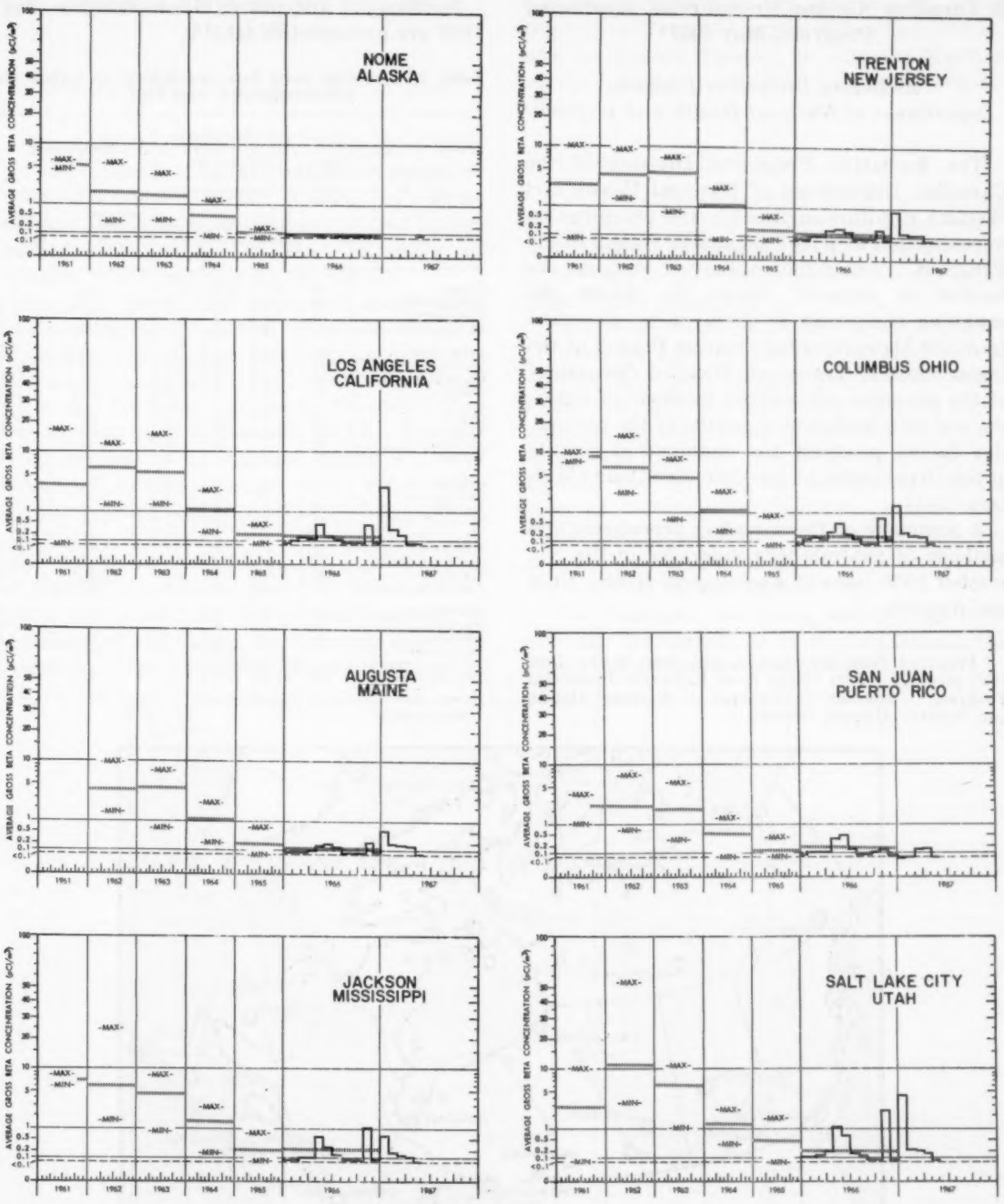

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1961–May 1967

2. Canadian Air and Precipitation Monitoring Program, May 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data in the June 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for May 1967 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, April 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	28	0.2	0.0	0.1	31	1.9
Coral Harbour	30	.1	.0	.0	11	0.2
Edmonton	31	.2	.0	.1	62	1.0
Ft. Churchill	31	.1	.0	.0	33	0.7
Ft. William	31	.1	.0	.1	41	1.2
Fredericton	31	.1	.0	.0	12	2.0
Goose Bay	31	.1	.0	.0	16	0.7
Halifax	31	.1	.0	.0	16	2.7
Inuvik	31	.1	.0	.0	32	1.0
Montreal	31	.2	.0	.1	33	1.9
Moosonee	31	.1	.0	.1	30	.8
Ottawa	31	.1	.0	.1	34	1.8
Quebec	31	.1	.0	.0	20	1.6
Regina	31	.2	.0	.1	147	1.3
Resolute	31	.1	.0	.0	NS	NS
St. John's, Nfld.	31	.1	.0	.0	18	2.1
Saskatoon	31	.2	.0	.1	61	1.2
Saulte Ste Marie	31	.1	.0	.1	33	4.1
Toronto	31	.2	.0	.1	29	1.7
Vancouver	31	.1	.0	.0	28	1.0
Whitehorse	31	.2	.0	.1	31	.9
Windsor	29	.1	.0	.1	32	1.4
Winnipeg	31	.1	.0	.1	10	.3
Yellowknife	31	.1	.0	.1	234	2.0
Network summary	738	0.2	0.0	0.1	43	1.5

NS, no sample.

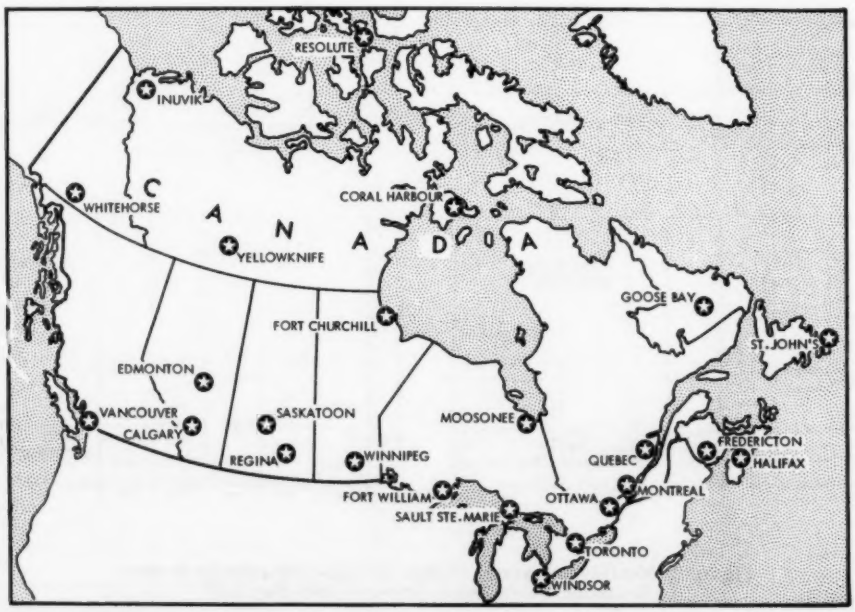

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program May 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average radioactivity at each station (*7*).

The maximum, minimum, and average beta-particle concentrations in surface air during May 1967 are presented in table 4.

Figure 4. Mexican air sampling locations

Table 4. Mexican gross beta radioactivity of airborne particulates May 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	15	0.1	0.1	0.1
Chihuahua	15	.2	< .1	.1
Ciudad Juárez	12	.2	< .1	.1
Ensenada	5	.2	< .1	(a)
Guadalajara	NS			
Guaymas	NS			
La Paz	11	.2	< .1	.1
Matamoros	NS			
Mazatlán	16	.3	.1	.1
Mérida	10	.1	.1	.1
México, D. F.	10	.1	< .1	.1
Neuvo Laredo	4	.3	.1	(a)
San Luis Potosí	NS			
Tampico	4	.1	< .1	(a)
Torréon	11	.1	< .1	.1
Veracruz	17	.2	< .1	.1

[a] An average is not presented for any station presenting less than 7 samples.
NS, indicates no sample collected, station temporarily shutdown.

4. Pan American Air Sampling Program May 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U. S. Public Health Service (PHS) to

Table 5. Gross beta radioactivity in surface air, PAHO May 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	18	0.06	0.01	0.03
Bolivia: La Paz	(b)			
Chile: Santiago	30	.05	.00	.02
Colombia: Bogota	19	.01	.00	.01
Ecuador: Guayaquil	(b)			
Jamaica: Kingston	16	.08	.02	.03
Peru: Lima	23	.03	.00	.02
Venezuela: Caracas	19	.04	.01	.02
West Indies: Trinidad	18	.05	.02	.03
Pan American summary	143	0.08	0.00	0.02

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
[b] No sample collected.

Figure 5. Pan American Air Sampling Program stations

assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station positions are shown in figure 5.

The May 1967 air monitoring results from the participating countries are given in table 5.

5. Fallout in the United States and Other Areas July–December 1966 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Monthly fallout deposition rates for strontium–90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active U.S. stations and other selected points in the Western Hemisphere (figure 6) covering the period from July through December 1966, are summarized in tables 6 and 7. All the stations of the 80th Meridian Network are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposed area of 0.076 m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of

[1] The data in this article compiled from "Fallout Program Quarterly Summary Report," HASL 182:A–1 to A-169; B–1 to B–22.

Table 6. Strontium-90 fallout in the United States, HASL, July-December 1966

Sampling location		Type of collection	Deposition (nCi/m^2)					
			July	Aug	Sept	Oct	Nov	Dec
Ala:	Birmingham	pot	0.13	0.22	0.12	0.03	0.06	0.05
Alaska:	Anchorage	column	.04	.10	.06	.01	.02	NS
	Barrow	column	.18	.04	.02	.01	.03	NS
	Cold Bay	column	.09	.18	.07	.04	.08	.10
	Fairbanks	column	.09	.06	T	.02	.04	.01
	Juneau	column	.12	.13	.26	.13	.03	NS
	Nome	column	.03	T	T	NS	NS	NS
Calif:	W. Los Angeles	pot	.03	T	.01	T	.05	.06
	San Francisco	column	.01	T	T	.01	.01	.06
Colo:	Denver	column	.50	.07	.08	.03	.09	.02
Fla:	Coral Gables	pot	.10	.07	NS	NS	NS	NS
	Miami	column	.23	.16	.05	.05	.07	NS
Hawaii:	Hilo	column	.46	.15	.09	.18	.13	NS
	Honolulu	pot	.03	.08	.07	.08	.36	.09
	Lihue	column	.08	.05	.02	.08	.06	NS
	Mauna Loa	column	.02	T	.01	.06	.02	NS
Ill:	Argonne	pot	.08	.06	.03	.05	.10	.07
La:	New Orleans	column	.20	.08	.07	.03	.03	NS
Minn:	International Falls	column	.06	.18	.05	.03	.03	NS
Mo:	Columbia	column	.07	.03	.09	.06	.06	.04
Mont:	Helena	column	.11	.08	.05	.04	.05	.04
N.J:	Westwood	pot	.15	.05	.12	.03	.08	.06
N.Y:	New York City	pot	.09	.12	.22	.08	.08	.10
N. Dak:	Williston	column	.19	.12	.05	.03	.01	NS
Ohio:	Wooster	pot	.14	.09	.04	.04	.02	.03
Okla:	Tulsa	pot	.07	.14	.06	.03	.01	.07
Ore:	Medford	column	.07	.06	.04	.04	.02	NS
S.C:	Columbia	column	.12	.08	.04	.07	.04	.07
S. Dak:	Vermillion	pot	.35	.20	.16	.10	.02	NS
Tex:	Dallas	column	.09	.10	.04	.02	.02	.04
	El Paso	column	.03	.07	.03	.02	.01	NS
	Houston	column	.07	.08	.05	.04	.04	NS
Utah:	Salt Lake City	pot	.09	.05	.14	.06	.07	.06
Va:	Sterling	column	.09	.04	.10	.04	.04	NS
Wash:	Seattle	pot	.12	.02	.08	.05	NS	NS
	Seattle	pot	.15	.03	.08	.06	.16	.16
	Forks *	column	.10	NS	NS	NS	NS	NS
Wis:	Green Bay	column	.23	.22	.04	.02	.06	.03

* Sampler located on Tatoosh Island until August 1966.
T, zero or trace.
NS, no sample reported.

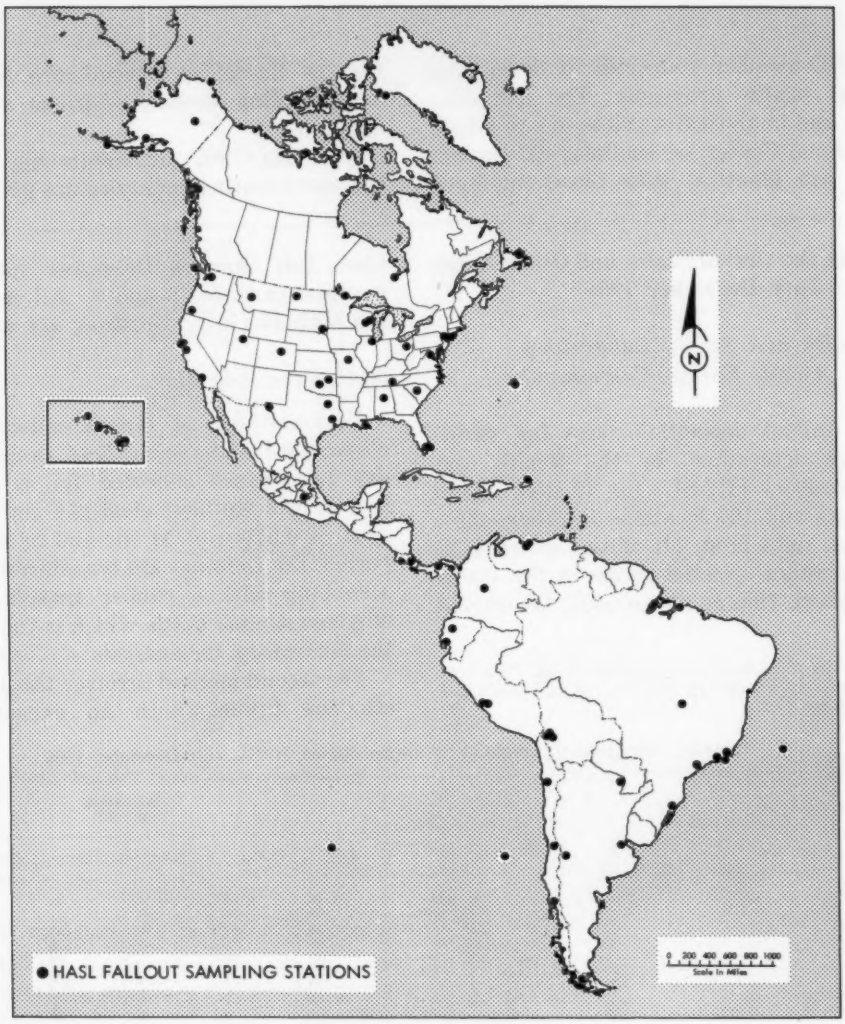

Figure 6. HASL fallout sampling stations in the Western Hemisphere

0.072 m^2, attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium–90 measurements obtained from samples collected by the two methods (*1*).

Other radionuclides

Laboratories at Westwood, N.Y., New York City, N.Y., and Seattle, Wash., have analyzed monthly precipitation samples for various radionuclides. The amount of precipitation at each station and the monthly deposition rates for iron–55, strontium–90, cerium–144, plutonium–238, and plutonium–239–240, at each station are presented in table 8.

Table 7. Strontium-90 fallout in North and South America, HASL, July-December 1966

Sampling location		Type of collection	Deposition (nCi/m²)					
			July	Aug	Sept	Oct	Nov	Dec
Argentina:	Buenos Aires	column	0.02	T	0.05	0.44	0.25	NS
	Formosa	column	.02	T	.05	.26	.13	NS
	Malargue	cloumn	.03	T	.04	.04	.12	NS
Bahamas:	Bimini	column	.06	0.12	.10	NS	.04	0.03
Bermuda:	Kindley AFB	column	.14	.05	.08	.06	.07	.06
Bolivia:	Chacaltaya	column	NS	NS	NS	NS	NS	NS
	La Paz (city	column	NS	NS	NS	NS	NS	NS
	La Paz (Ovejuyo)	column	NS	NS	NS	NS	NS	NS
Brazil:	Belem	column	.03	.02	.03	.24	.06	NS
	Brasilia	pot	NS	NS	NS	NS	NS	NS
	Itaici Sao Paulo	pot	.04	.08	NS	.16	NS	NS
	Nova Friburgo	pot	.03	.15	.08	.28	NS	NS
	Rio de Janeiro	column	.09	.23	.20	.86	NS	NS
	San Jose Dos Compos	pot	.02	.07	.10	NS	NS	NS
	Sao Leopoldo	pot	.12	.14	.07	.08	NS	NS
	Trindade Island	column	NS	NS	NS	.83	NS	NS
Canada:	Moosonee	column	.12	.03	.02	.01	NS	NS
	Newfoundland [b]	column						
Canal Zone:	Balboa [c]	column	.02	T	T	.02	.04	.03
Chile:	Antofagasta	column	.01	NS	.01	.01	.01	.01
	I. Alejandro Selkirk [d]	column	NS	.11	.11	.03	.08	NS
	Easter Island	column	.06	.05	.06	.07	.24	NS
	Puerto Montt	column	.24	.11	.22	.14	.11	NS
	Punta Arenas	column	T	.02	.05	.03	.04	NS
	Santiago	pot	.04	.01	.01	.04	.02	NS
	Santiago	column	.03	.06	NS	.09	.01	.01
Colombia:	Bogota	pot	T	T	T	NS	NS	NS
Costa Rica:	Turrialba	column	.01	NS	.02	.06	.05	NS
Equador:	Guayaquil	column	.01	.05	NS	.01	.02	NS
	Quito	column	.01	T	T	.01	T	.01
Greenland:	Thule	column	.04	.12	.02	.02	.01	NS
Iceland:	Keflavik	column	.17	.14	.12	.03	.09	.06
Mexico:	Mexico City	column	.09	.09	.02	.02	.01	.01
Peru:	Lima	column	.01	[a].01	[a].01	.04	.05	.02
	Lima	column	.01	.03	.03	.12	.02	NS
Puerto Rico:	San Juan	column	.10	.06	.07	.03	.04	.06
Venezuela:	Caracas (site 1)	column	.06	.02	.02	.03	.02	.03
	Caracas (site 2)	column	[a].03	[a].02	.02	.01	.03	NS

[a] Indicates proportioned from originally consolidated data.
NS, no sample reported.
T, zero or trace.
[b] Collections terminated April 1966.
[c] Changed from Miraflores.
[d] Isla Robinson Crusoe.

Table 8. Radiochemical analyses of precipitation samples at 3 U.S. sites, HASL July–December 1966

	July	Aug	Sept	Oct	Nov	Dec
Precipitation (cm)						
New York, New York	3.18	4.80	22.40	11.78	8.81	8.08
Washington, Seattle	2.77	0.25	3.66	6.63	NS	NS
Iron-55 (nCi/m²)						
New Jersey, Westwood	1.72	0.86	0.84	0.36	0.48	0.52
Washington, Seattle	1.03	0.83	1.07	0.96	NS	NS
Strontium-90 (nCi/m²)						
New Jersey, Westwood	0.15	0.05	0.12	0.03	0.08	0.06
New York, New York	0.09	0.12	0.22	0.08	0.08	0.10
Washington, Seattle	0.02	0.08	0.05	NS	NS	NS
Cerium-144 (nCi/m²)						
New Jersey, Westwood	0.18	0.10	NS	NS	NS	NS
Washington, Seattle	0.27	0.11	0.10	0.13	NS	NS
Plutonium-238 (nCi/m²)						
New York, New York	0.00030	0.00027	0.00021	0.00017	NS	NS
Washington, Seattle	<0.0005	0.0004	0.0006	<0.0002	NS	NS
Plutonium-239,240 (nCi/m²)						
New York, New York	0.00249	0.00221	0.00146	0.00176	NS	NS
Washington, Seattle	0.0016	0.0006	0.0019	0.0014	NS	NS

[a] Data suspect.
NS, no sample reported.

6. Plutonium in Airborne Particulates January–March 1967

National Center for Radiological Health
U.S. Public Health Service

The Radiation Surveillance Network (RSN) of the National Center for Radiological Health, Public Health Service, located at Rockville, Md., is continuing routine analysis for plutonium in airborne particulates. These analyses were initiated during 1965 as part of the mission to establish, maintain, and operate a national surveillance network to measure radioactivity in the environment.

Air filters from 11 RSN stations are analyzed monthly for plutonium. Each daily filter is counted for gross beta radioactivity and for gamma-ray emitters by gamma-ray spectroscopy 4 to 5 days after collection. For plutonium analysis, a monthly composite is made of one-half of each individual sample for each station. Each composite, representing 10,000 to 20,000 cubic meters of air, is analyzed by gamma-ray spectroscopy prior to the plutonium analysis.

Table 9. Plutonium in airborne particulates January–March 1967

Sampling location	Plutonium content [a] (pCi/1,000 m³)		
	January	February	March
N. Y: Buffalo	0.033	0.053	0.052
N. C: Gastonia	.046	.066	.086
Md: Rockville	.033	.053	.055
S. Dak: Pierre	.040	.041	.063
La: New Orleans	.055	.074	.098
Tex: Austin	.058	.053	.092
Colo: Denver	.053	.073	[b] 2.259
Alaska: Anchorage	.104	.078	.087
Ariz: Phoenix	.053	.139	.115
Hawaii: Honolulu	.039	.042	.054
Wash: Seattle	.063	.072	.044

[a] Plutonium includes ^{238}Pu, ^{239}Pu, and ^{240}Pu.
[b] This sample was counted by alpha-particle spectrometry for individual isotopes of plutonium. The approximate isotopic breakdown is 1.85 pCi/1,000 m³ 239–240Pu and 0.41 pCi/1,000 m³ 238Pu.

Details of the method of collection and radiochemical analyses were presented in an earlier report (*9*). The results for January through March 1967 are presented in table 9.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological material and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring in the vicinity of nuclear facilities.

Strontium-90 in Human Bone, October-December 1966

National Center for Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium–90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown

[1] Period during which death or surgical procedure occurred.

Figure 1. Geographical regions for the PHS Human Bone Sampling Network

Table 1. Strontium-90 in human bone, deaths and surgical procedures during October–December 1966

Sampling region and State of residence	Sex	Bone type [a]	Age at death [b] (years)	Cause of death	Strontium-90, pCi/g of:		
					Ash ±2σ error	Calcium	Bone
NORTHEAST:							
N. Y.	M	V	3	Neuroblastoma	0.78 ±0.11	2.20	0.07
Mass.	F	V	4	Leukemia	1.53 ± .19	4.35	.12
N. J.	M	V	4	Acute leukemia	.97 ± .09	2.66	.08
N. Y.	F	V	5	Wilm's tumor	1.21 ± .10	3.30	.12
N. Y.	F	V	6	Acute leukemia	.79 ± .10	2.16	.12
N. H.	M	V	6	Cerebral contusion	1.20 ± .10	3.44	.12
Pa.	M	V	8	Sarcoma of the mesentery	.94 ± .12	2.62	.08
N. Y.	F	V	9	Intracranial hemorrhage	.76 ± .09	2.09	.07
N. Y.	M	V	10	Acute leukemia	1.07 ± .07	2.97	.12
R. I.	M	V	11	Acute leukemia	1.48 ± .17	4.07	.09
N. H.	M	V	11	Brain tumor	.86 ± .07	2.36	.09
Pa.	M	V	11	Multiple injuries	.68 ± .07	1.85	.07
Mass.	F	V	14	Infectious hepatitis	1.61 ± .10	4.03	.23
N. Y.	M	V	14	Acute leukemia	.96 ± .07	2.52	.13
Pa.	F	V	15	Asphyxiation	.92 ± .07	2.44	.14
N. Y.	M	V	16	Reticulum cell sarcoma	.86 ± .07	2.25	.11
Conn.	M	V,R	18	Subdural hematoma	.73 ± .08	2.12	.12
Pa.	F	V	19	Nephrosclerosis	.81 ± .06	2.14	.13
N. Y.	M	V	19	Acute leukemia	.93 ± .09	2.44	.14
Conn.	M	V,R	20	Head injury	.77 ± .07	1.93	.11
R. I.	F	V,S	21	Brain abscess	.64 ± .06	1.78	.07
N. Y.	F	V	22	Hodgkin's disease	.55 ± .08	1.46	.08
Pa.	F	V	23	Nephrosclerosis	.61 ± .07	1.61	.08
Mass.	M	V	24	Cerebral laceration	.83 ± .06	2.19	.13
Conn.	M	V	24	Laceration of brain	.86 ± .08	2.12	.11
Mass.	M	V	24	Head injury	.82 ± .07	2.22	.09
SOUTHEAST:							
Md.	F	V	2	Digoxin intoxication	2.20 ±0.22	6.48	0.19
Md.	M	V	6	Acute appendicitis	.83 ± .08	2.24	.11
Md.	F	V	10	Craniocerebral injury	.84 ± .09	2.30	.11
Md.	M	V	13	Craniocerebral injury	.99 ± .07	2.73	.12
Md.	M	V	15	Multiple injuries	1.12 ± .10	3.07	.15
Ky.	F	V	16	Biliary atresia	1.36 ± .09	3.87	.11
Md.	M	V	16	Craniocerebral injury	1.67 ± .11	4.36	.23
Md.	M	V	16	Craniocerebral injury	1.07 ± .10	2.95	.16
Md.	M	V	18	Gunshot wound of head	1.02 ± .07	2.69	.15
Md.	F	V	24	Acute myocarditis	.49 ± .05	1.30	.07
CENTRAL:							
Wis.	M	V	0 (10 mo.)	Congenital heart disease	1.19 ±0.16	3.53	0.10
Wis.	M	V	0 (11 mo.)	Acute leukemia	1.19 ± .19	3.52	.10
Ohio	F	V	1	Pneumococcal meningitis	1.57 ± .16	4.41	.14
Ohio	F	V	2	Aplastic anemia	1.33 ± .16	3.71	.11
Wis.	M	V	2	Acute leukemia	.73 ± .10	2.23	.06
Wis.	F	V	4	Congenital heart disease	.96 ± .13	3.11	.08
Ohio	F	V	5	Lymphosarcoma	.83 ± .12	2.40	.07
Ohio	F	V	5	Epidural hemorrhage	2.00 ± .20	6.73	.23
Ohio	M	V	8	Acute leukemia	1.28 ± .09	3.61	.12
Ohio	M	V	9	Encephalomalacia	.88 ± .07	2.49	.09
Ohio	F	V	11	Mediastinal neoplasm	.70 ± .10	1.96	.05
Ohio	M	V	21	Glomerulonephritis	.60 ± .08	1.67	.09
Minn.	F	V	22	Status asthmaticus	.60 ± .06	1.66	.08
Ohio	M	V	22	Head injury	.75 ± .08	2.01	.12
Ohio	F	V	23	Subdural hematoma	.54 ± .06	1.35	.09
Ohio	M	V	23	Cerebral aneurysm	.68 ± .05	1.24	.08
DELTA:							
La.	F	V	4	Acute leukemia	.94 ±0.04	3.09	0.04
La.	M	V,R	12	Monocytic leukemia	.62 ± .09	1.85	.05
La.	M	V	17	Glomerulonephritis	2.38 ± .13	6.46	.28
La.	M	V	19	Epidural hematoma	.78 ± .08	2.09	.11
La.	F	V	22	Cerebellar sarcoma	.42 ± .07	1.11	.05
La.	F	R	23	Preeclampsia	.47 ± .04	1.16	.20
La.	F	V	23	Pelvic peritonitis	.66 ± .07	1.80	.09
NORTHWEST:							
Ore.	M	V	0 (9 mo.)	Sudden unexplained death	1.77 ±0.22	5.45	0.12
Ore.	M	V	1	Smoke inhalation	1.08 ± .12	4.32	.15
Ore.	M	V	11	Drowning	1.13 ± .08	3.24	.10
Ore.	M	V	12	Rupture of aorta	.64 ± .10	1.81	.06
Ore.	F	V	16	Neck fracture	.65 ± .08	1.75	.10
Ore.	M	V	17	Rupture of aorta	.94 ± .07	2.60	.13
Ore.	F	H,F	18	Multiple injuries	.71 ± .05	1.97	.37
Alaska	M	R	18	(c)	1.47 ± .16	3.81	.63
Ore.	M	SK	20	Head injuries	.51 ± .04	1.37	.23
Ore.	M	V	23	Internal injuries	.68 ± .06	1.84	.08
Wash.	F	H,F	25	Multiple injuries	.28 ± .03	0.74	.11
SOUTHWEST:							
Tex.	F	V	19	Hyperemesis gravidarum	.76 ± .09	2.03	.12

[a] Type of bone: R, rib; V, vertebrae; S, sternum; F, femur; SK, skull; H, humerus.
[b] Age given as of last birthday prior to death.
[c] Sample obtained from surgical procedure.

their bone strontium–90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Most speciments received to date have been vertebrae and ribs. Efforts to collect long bones for comparison of results with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the National Center for Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxylate. The strontium–90 content is then calculated (*3*) from the yttrium–90 radioactivity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium–90) are analyzed periodically and cross-check analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium–90 in individual bones from persons dying during the fourth quarter (October–December) of 1966 along with other pertinent data (place of residence, sex, bone type, and cause of death), are presented in table 1 in order of increasing age within each geographical sampling region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium–90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration. Additional data for the first half of 1966 (January–June) not reported in earlier tabulations, is given in table 2.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1966	February 1967
April–June 1966	March 1967
July–September 1966	July 1967

Table 2. Supplemental data, strontium-90 in human bone, first half 1966[a]

Sampling region and State of residence	Sex	Bone type	Age at death (years)	Cause of death	Strontium-90, pCi/g of:		
					Ash ±2σ error	Calcium	Bone
NORTHEAST:							
1st quarter:							
N. Y.	F	V	2	Asphyxiation	1.39 ±0.17	3.80	0.13
Mass.	M	V	7	Cystic fibrosis	1.40 ± .13	3.95	.14
N. Y.	M	V	12	Head injury	1.39 ± .17	3.80	.09
Mass.	M	V	23	Mental deficiency	.63 ± .07	1.67	.08
CENTRAL:							
1st quarter:							
Wis.	M	V	1	Interstitial pneumonia	1.70 ± .15	4.86	0.14
2nd quarter:							
Minn.	F	V	0	Familial nephrosis	1.47 ± .21	4.60	0.14

[a] Repeated and more accurate determination of earlier reported value.

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(5) HALLISEY, R. M., and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–4 (August 1967).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Argonne National Laboratory, National Reactor Testing Station, Portsmouth Area Gaseous Diffusion Plant, and the Savannah River Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual. The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Argonne National Laboratory July–December and Annual Summary 1966[2]

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occuring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July–December and Annual Summary 1966," University of Chicago, Lemont, Ill.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivities in air filter samples are summarized in table 1. The alpha-particle concentrations were due principally to naturally-occurring radionuclides, and were normal both on and off the site and in the range found in previous years. The beta-particle concentration was due primarily to fission products from nuclear detonations. The increased beta radioactivities in the second and fourth quarters of 1966 were produced by the shorter-lived fission products which originated in the Chinese nuclear tests of May 9 and October 27, 1966. The average beta radioactivity for the year, 0.16 pCi/m^3, was about 0.1 pCi/m^3 less than

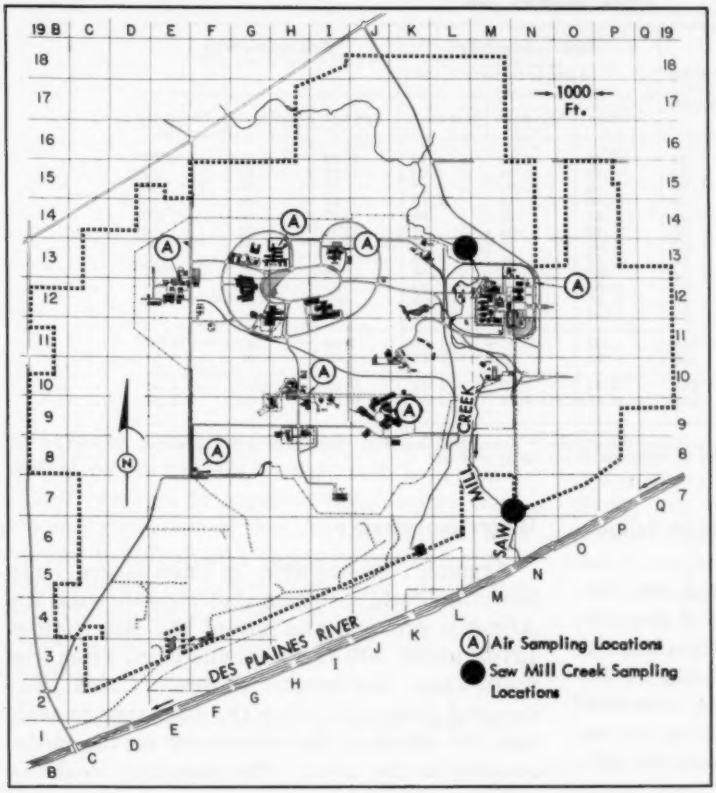

Figure 1. Sampling locations on the site of Argonne National Laboratory

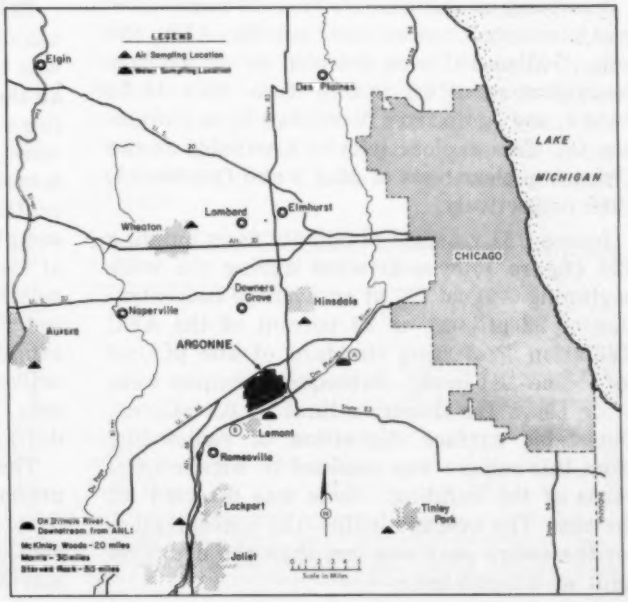

Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

Table 1. Alpha and beta radioactivity in air-filter samples, Argonne, July–December and annual summary 1966 [a]

Period	Location	Number of samples	Alpha radioactivity (pCi/m^3) multiply by 10^{-3}			Beta radioactivity (pCi/m^3)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	onsite	24	0.59	0.27	1.19	0.20	0.09	0.30
	offsite	22	.52	.24	1.03	.21	.12	.33
August	onsite	26	.53	.32	0.87	.10	.05	.15
	offsite	23	.60	.15	1.12	.10	.03	.16
September	onsite	26	.57	.25	.88	.07	.04	.10
	offsite	22	.50	.31	.77	.08	.05	.10
October	onsite	23	.55	.35	.75	.05	.04	.07
	offsite	19	.55	.31	.85	.05	.03	.07
November	onsite	24	.53	.23	1.04	.53	.05	1.94
	offsite	23	.55	.29	.83	.55	.04	2.54
December	onsite	23	.37	.21	.64	.08	.03	.30
	offsite	21	.46	.16	1.31	.09	.04	.23
July-December	onsite	146	.52	.21	1.19	.19	.03	1.94
	offsite	130	.53	.15	1.31	.18	.03	2.54
Annual summary	onsite	288	0.47	0.10	1.19	0.15	0.02	1.94
	offsite	252	0.47	0.14	1.31	0.16	0.02	2.54

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

during 1965 due to a general decline in fallout 1966, respectively.

The similarity between alpha, beta, and fission product radioactivities on and off the site indicates that Argonne did not add significantly to the particulate airborne radioactivity of the environment. Significant releases by Argonne would have been detected in the form of an increase in the onsite radioactivity over the offsite radioactivity.

Sampling on charcoal for gaseous radioiodine was conducted continuously on the ANL site only. Iodine–131 was detected at an average concentration of 0.1 pCi/m^3 from May 15 to June 9, and again from November 11 to November 18. This radioactivity is attributed to the Chinese nuclear tests of May 9 and October 27, 1966 respectively.

Iodine–131 released accidently from building 330 (figure 1) was detected during the week beginning August 23, at an average concentration of 38 pCi/m^3, or 38 percent of the AEC Radiation Protection standard of 100 pCi/m^3 for iodine–131 in air. Subsequent samples were at or below the detection limit of 0.1 pCi/m^3. Detectable surface deposition of radioiodine from this release was confined to within 1,000 yards of the building. None was detected off the site. The average iodine–131 concentration for the entire year was less than the detection limit of 0.1 pCi/m^3.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500-yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the radioactivity in the creek. The sampling locations are shown in figure 2.

Below the wastewater outfall the creek was usually sampled three times weekly. Since it was impractical to analyze all the samples for all the nuclides and elements desired, equal portions of the three samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Additional samples were collected when unusual amounts of radioactivity were expected or found in the wastewater. Above the site, samples were collected at weekly intervals, and at least one sample each month was analyzed for each radioactive nuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during 1966 are given in table 2.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, thorium, and plutonium. The alpha radioactivities due to these elements are summarized in table 3. As indicated in the table,

Table 2. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne July–December and annual summary 1966

Month	Location [a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	3	1.9	0.5	4.0	16	10	23
	Downstream	18	2.5	1.2	4.3	440	18	9,600
August	Upstream	5	1.8	.9	3.0	10	6.7	13
	Downstream	12	1.9	1.1	2.2	17	12	25
September	Upstream	3	2.0	.9	3.5	9.7	7	12
	Downstream	15	1.3	.2	2.1	15	12	23
October	Upstream	2	28	1.5	42	13	12	13
	Downstream	12	1.3	.4	1.4	12	9.4	15
November	Upstream	2	1.5	1.2	1.7	13	13	14
	Downstream	12	1.3	.8	1.8	16	12	23
December	Upstream	2	2.5	2.1	2.9	8.6	5.8	11
	Downstream	15	2.1	1.8	2.7	12	9.1	17
July-December	Upstream	17	2.1	.5	4.2	12	5.8	23
	Downstream	81	1.8	.2	4.3	85	9.1	9,600
Annual summary	Upstream	42	2.1	0.1	4.2	41	5.8	23
	Downstream	159	2.6	0.2	12.7	54	9.1	9,600

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

the average as well as maximum amounts of these elements present in the creek as a result of their presence in Argonne waste-water were very low compared to the AEC standards. The average uranium and thorium concentrations below the outfall during 1966 were about one-half of those during 1965, while the plutonium concentration averaged about five times greater.

Table 3. Alpha-emitting elements in Sawmill Creek water Argonne, July–December 1966

Element	Location [a]	Number of samples	Concentration (pCi/liter)			Average as a percent of AEC Standard
			Average	Minimum	Maximum	
Uranium	Upstream	12	1.1	0.4	1.6	0.003
	Downstream	78	1.0	0.5	1.8	0.003
Plutonium	Upstream	6	------	------	<0.05	
	Downstream	48	<0.05	<0.05	0.21	<0.001
Thorium	Upstream	6	<0.05	<0.05	0.06	<0.003
	Downstream	48	<0.05	<0.05	0.14	<0.003

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

In addition to the natural beta radioactivity in the creek, beta radioactivity from nuclear detonations was detected at both sampling locations, and beta radioactivity from Argonne waste-water was found below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. It is estimated that fallout radioactivity added an average of about 5 pCi/liter to the beta radioactivity at both locations (fallout is added to the water below the outfall directly from the air as well as by above-site water), and that the Argonne contribution below the outfall averaged approximately 45 pCi/liter, about nine times more than during 1965. A release of promethium–147 resulted in the maximum concentration (9,600 pCi/liter) of beta radioactivity for July. This level amounts to 4.8 percent of the annual average AEC radiation protection standard for this radionuclide.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne waste water to the environmental radioactivity. The Des Plaines River was sampled weekly, when water was available, above and below the mouth of Sawmill Creek to detemine if the radioactivity in the creek had any effect on the radioactivity in the river. The average total radioactivity in these two rivers are summarized in table 4 for the second half of 1966.

Table 4. Average radioactivity in Des Plaines and Illionis River water, Argonne, 1966

Location	Concentration (pCi/liter)	
	Non-volatile alpha radioactivity	Non-volatile beta radioactivity
Des Plaines River [a] (above Sawmill Creek)	2.7	19
Des Plaines River [b] (below Sawmill Creek)	2.6	16
Illinois River [c]	4.1	12

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] Average for samples collected at three locations (McKinley Woods State Park, Morris, and Starved Rock State Park) on May 12, 1966.

Dilution of Sawmill Creek water in the Des Plaines River was sufficient to reduce the radioactivity in the creek to undetectable levels in the river. The alpha radioactivity in the Des Plaines River was normal and in the range previously found. The natural beta radioactivity in the Des Plaines River is about 5–10 pCi/liter and the additional radioactivity, about 10 pCi/liter on the average, resulted from fallout. The total radioactivity in samples of the Illinois River water collected on May 12 was similar to that found in other bodies of water in the area and no radioactivity originating at Argonne could be detected.

Milk monitoring

Three samples of raw milk produced in the area were collected monthly (except in May, when an additional collection was made after the appearance of fresh fallout and in December, when one sample was obtained) and analyzed for the fission products usually present. These fission products were all due to fallout from nuclear detonations and their presence in milk was not related to Argonne operations. The long-lived fission products, cesium–137 and strontium–90 were present in all samples. Their average concentrations, 46 pCi/liter for cesium–137 and 8.2 pCi/liter for strontium–90 were not greatly different from those found in 1965.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	September 1966
January–June 1966	March 1967

2. National Reactor Testing Station July–December and Calendar Year 1966[3]

Health and Safety Division
U.S. Atomic Energy Commission
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during 1966 did not contribute significantly to environmental radiation or radioactivity concentration levels, which remained well below levels defined as thresholds of concern by the Federal Radiation Council (FRC). The radiation protection standards used at the NRTS, which are established in AEC Manual Chapter 0524, are based on FRC recommendations. In choosing applicable standards for drinking water, credit has been taken for the fact that no significant quantities of radium–226 or radium–228 have been released to the environs by NRTS operations. The concentrations of radioactivity reported include contributions from all sources. No attempt has been made to separate activity contributed by NRTS operations from that contributed by natural sources of radioactivity or by fallout from weapons debris. Samples of air, water, and milk are collected routinely at stations shown in figure 3. The results of the analyses performed on these samples are shown in table 5.

Aerial survey

Results obtained from a detailed aerial survey performed over the NRTS in early 1966 confirmed similar measurements obtained in 1959, and again showed no significant change in environmental radiation background that could be attributed to NRTS operations. Radiation measurements were made along parallel courses 1 mile apart at 500-feet altitude. The survey was performed by an AEC contractor who operates a specially equipped aircraft capable of detecting trace quantities of radioactivity and identifying the material detected. Small variations in the natural background were again noted over varying terrain and were clearly identified with naturally occurring radioactivity in rock and soil formations.

Offsite water monitoring

Low-level liquid wastes from various operating facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the NRTS and, as an added safeguard, offsite underground water samples are collected and

[3] Summarized from "Environmental Monitoring Report No. 19, Third and Fourth Quarter and Annual Summary 1966." U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

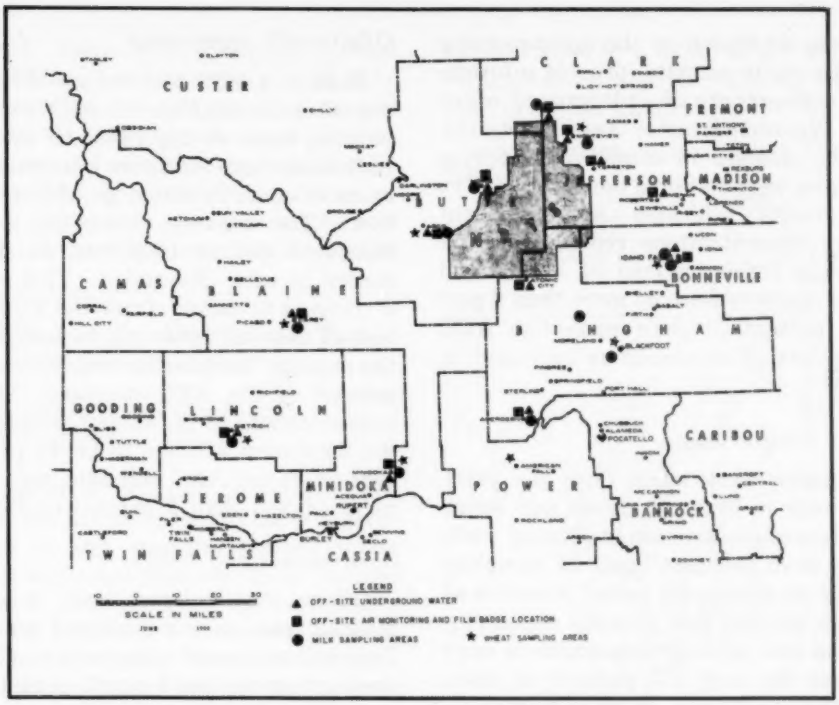

Figure 3. Environmental monitoring stations, National Reactor Testing Station

analyzed regularly. Most of these samples are taken from an area southwest of the prevalent direction of underground water flow. Since the beginning of the offsite sample collections in 1952, there has been no evidence of any NRTS contribution to the natural radioactivity in the offsite water.

Through continuing studies of the underground water on the NRTS additional knowledge of the directional flow and flow rates have been obtained. As a result of this knowledge the number and locations of sampling points have been reduced to those populated areas nearest the site boundaries. Samples from

Table 5. Environmental monitoring data for the National Reactor Testing Station, July–December and calendar year 1966

Type of sample and units	Number of stations	July–December 1966					Calendar year 1966			
		Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC radiation protection standard
Offsite underground water, (pCi/liter)	12	Semiannual	Alpha	3	< 3	< 3	3	< 3	< 3	100
			Beta	6	7	< 7	6	7	< 7	100
Onsite production well water, (pCi/liter)	22	Biweekly	Alpha	3	6	< 4	3	6	< 4	3,000
			Beta	6	17	< 7	6	125	< 8	3,000
Offsite air, (pCi/m³)	12	Continuous	Beta-gamma	1.6	54	< 6	1.6	54	< 8	100
Offsite milk, (pCi/liter)	12	Monthly	Iodine-131	3.6	25	< 5	3.6	60	< 5	100
			Iodine-131	20	63	<22	20	63	<21	100
			Strontium-90	1.5	13	< 7	1.5	17	< 9	200
Offsite area monitoring badges, (mR)	12	Monthly	Gamma	10	<10	<10	10	<10	<10	170/yr

these locations as shown on the accompanying map, plus the onsite samples, provide information on the radioactivity of underground water leaving the National Reactor Testing Station.

Due to the changes in sampling procedure only 12 samples were collected during 1966. The analytical results indicated no significant change from concentrations recorded during 1965. Average concentrations of alpha- and beta-particle emitters were no more than 3 percent and 7 percent of their respective AEC radiation protection standards as indicated in table 5.

Onsite water monitoring

Onsite samples were taken from the plant production wells in order to detect and define possible sources of contamination. During 1966, 430 samples were collected from 22 sampling stations, most on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta-particle emitters were no more than 0.2 and 0.3 percent of their respective AEC standards, again reflecting no change from the previous year.

Air monitoring

During 1966, 153 air samples were collected and evaluated for airborne alpha-particle emitters. A gross alpha particle determination was made on filter-paper samples after a sufficient time had elapsed to permit the decay of the short-lived daughter products of radon and thoron. The filter-paper samples were counted for alpha-particle emission by scintillation counters. The average measured concentrations of alpha radioactivity in air was .002 pCi/m^3 or 5 percent of the AEC standard. The radiation protection standard used is that for uncontrolled areas and for gross alpha radio activity for which no analyses for specific isotopes have been made. The alpha radioactivity is attributed primarily to long-lived radioactive elements naturally present in the environment.

Results of the data reported from the 12 offsite radiation telemetry stations indicate that the average concentrations of gaseous iodine–131 and particulate radioactivity in the atmosphere was less than 8 percent of the AEC radiation protection standards.

Offsite milk monitoring

Routine analyses of iodine–131 and strontium–90 concentrations in milk continued on a monthly basis during 1966. Of the 139 routine radioiodine analyses, only 7 samples were found to have concentrations greater than 20 pCi/liter. The highest iodine–131 concentration measured during 1966 was 63 pCi/liter recorded in early November. This increase was attributed to fallout from the Chinese nuclear test of October 1966. As indicated in table 5, the average iodine–131 levels do not exceed 21 percent of the AEC standard. Strontium–90 concentrations in the same 139 samples showed the maximum activity to be 17 pCi/liter of 9 percent of the AEC standard with an average value of less than 5 percent of this standard.

Area monitoring badges

Offsite film badges were collected on a monthly basis during the first 9 months of 1966. Thermoluminescent dosimeters (TLD) were used during the last 3-month period. The TLD's were chosen to replace the film badges presently used in the NRTS environmental monitoring program. Current plans call for reading the dosimeters on a semiannual basis except in the case of an accident or known exposure.

The radiation exposure at a single location for any month as measured by film badges or TLD's was <10 mR of gamma radiation. The minimum detection limit for the calendar year was 120 mR of gamma radiation, based on 12 changes and a detection limit of 10 mR gamma radiation on each film or TLD. For the purpose of calculating the maximum dose, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true dose at that location. Natural background radiation levels at film badge locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100–150 mR/yr. This indicates that NRTS operations have added no significant external radiation to the surrounding areas.

Wheat monitoring

Monitoring of wheat in southern Idaho con-

tinued in 1966. Analysis of 8 samples showed strontium–90 levels ranging from 6 to 14 pCi/kg with an average of 10 pCi/kg. Cesium–137 and manganese–54 activity in the same samples were at or below the detection limit of 35 pCi/kg for cesium–137 and 100 pCi/kg for manganese–54. A comparison of data from the previous year shows that the levels of strontium–90 has decreased by a factor of 2. Cesium–137 and manganese–54 activities are no longer detectable by routine analyses.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December and calendar year 1965	July 1966
January–June 1966	January 1967

3. Portsmouth Area Gaseous Diffusion Plant July–December 1966[4]

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium–234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 4. Monthly water samples are collected at 13 stations within 5 miles of the plant.

Average airborne alpha radioactivity showed a reduction during the second half of 1966 when compared with the first half of 1966. The alpha radioactivity dropped from 7.3 to <5.0 percent of the AEC radiation protection standard. The airborne beta-gamma activity remained essentially the same as the previous 6-month average.

During this period, both the average alpha and beta-gamma radioactivities in water samples showed little change from those for the previous period. The average radioactivity monitored in water amounted to 0.09 percent of the AEC standards for alpha particle and 0.03 percent for beta particle + gamma-ray emitters.

[4] Data summarized from B. Kalman and S. H. Hulett, "Environmental Radiation Levels and Concentrations, Second Half and Annual Summary 1966," GAT–529 (February 13, 1967).

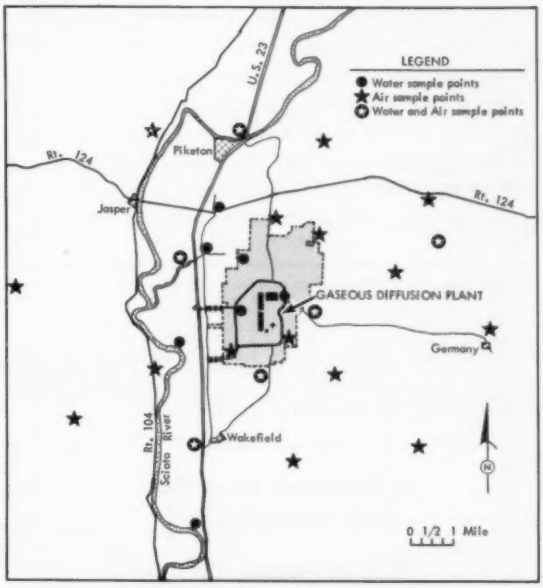

Figure 4. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

Average background exposure rates declined to 17.4 percent of the AEC standard (0.5 rem/yr) during 1966. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities and the continuing decline in exposure rates which followed the moratorium in nuclear testing activities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma radioactivity levels in air and water are summarized in table 6. The external gamma-ray levels measured at the air sampling locations shown in figure 4,

are also summarized in table 6. The overall average concentrations and background exposure rates for 1966 and the overall 1965 averages are presented in table 7.

Table 6. Environmental radioactivity, Portsmouth Plant July–December 1966

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard [a]
Air					
Alpha radioactivity (pCi/m³)	125	0.2	< 0.1	<0.1	< 5.0
Beta-gamma radioactivity (pCi/m³)	125	2.4	< .1	< .1	0.01
Water					
Alpha radioactivity (pCi/liter)	71	284	< .5	18.1	.09
Beta-gamma radioactivity (pCi/liter)	71	135	<14.0	6.9	.03
Background exposure [b] (mrad/hr)	126	.024	.011	.015	17.1

[a] The applicable AEC radiation protection standards are as follows:

Air (alpha)	2 pCi/m³
Air (beta-gamma)	1×10^3 pCi/m³
Water (alpha)	2×10^4 pCi/liter
Water (beta-gamma)	2×10^4 pCi/liter
External beta-gamma	0.5 rem/yr (approx. 0.06 mrad/hr)

[b] Measurements were made with an open-shield Geiger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration standard.

Table 7. Comparison of average concentrations, Portsmouth Plant, 1965 and 1966

Type of monitoring	Percent of AEC radiation protection standard [a]			
	1966			1965
	First half	Second half	Calendar year	Calendar year
Air				
Alpha radioactivity	7.3	< 5.0	1.4	13.8
Beta-gamma radioactivity	0.03	0.01	0.02	0.03
Water				
Alpha radioactivity	.07	.09	.09	.30
Beta-gamma radioactivity	.07	.03	.05	.32
Background exposure extrapolated to 3 feet above ground level	17.7	17.1	17.4	27.7

[a] See footnote (a) of table 6.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	July 1966
January–June 1966	January 1967

4. Savannah River Plant July–December 1965[5]

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, four reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low-level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200-square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the maximum permissible concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the daily intake guides recommended by the Federal Radiation Council (FRC).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity cannot be readily distinguished from weapons tests fallout, and both are included in the reported concentra-

[5] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, July–December 1966" (DPST–67–30–1).

tions. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by weekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25-mile radius from the center of the plant (figure 5). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; they are reference points for determining background radioactivity levels (figure 6). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and SRP releases.

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separations areas, was obscured by fallout from nuclear weapons tests. The influence of the weapons tests which resumed in September 1961 is shown in figure 7. The rises in early 1964, 1965, and 1966, were the result of the anticipated spring increases in

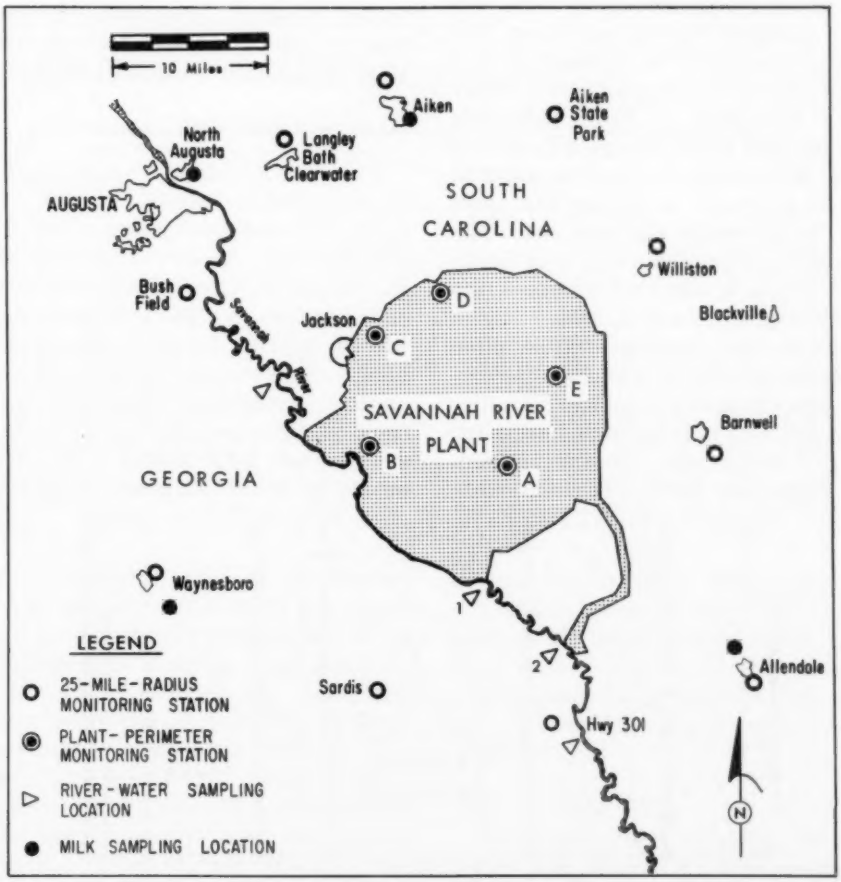

Figure 5. Environmental sampling locations, Savannah River Plant

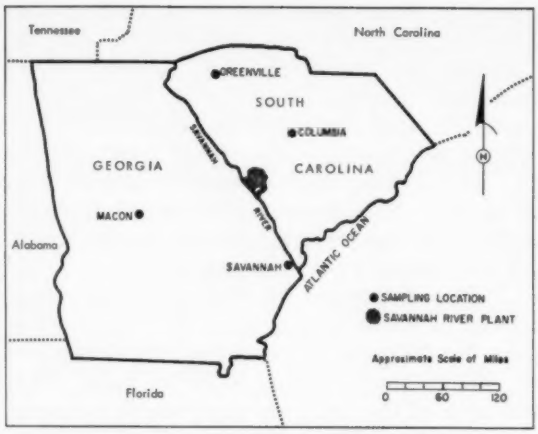

Figure 6. Distant air monitoring station Savannah River Plant

the mixing of stratospheric debris into the troposphere. Evidence of fallout from the Chinese nuclear detonation of October 27 was first detected at the plant site during a 72-hour period ending November 7, 1966. Filterable beta-particle emitters in air increased from 0.03 to 0.78 pCi/m³, and evidence of barium–140 and lanthanum–140 appeared in gamma-ray spectrograms of high-volume air samples. The maximum airborne concentration of beta radioactivity (1.23 pCi/m³), occurred during a 24-hour period ending November 8, 1966.

Radioactivity in air, determined from filter analyses, is shown in table 8. The July–December 1966 concentrations of filterable beta radioactivity (0.09 pCi/m³) and alpha radioactivity (0.0007 pCi/m³) in air were 0.1 and 1.8 percent of the respective MPC. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 1.1 percent of the MPC. Iodine–131 concentrations in routine air samples were less than 0.02 pCi/m³, the lower detection limit, throughout the period.

Deposition of weapons tests fallout during the last half of 1966 totaled 27 nCi/m² at plant perimeter locations and 21 nCi/m² at 25-mile radius locations; comparable values for the first half of 1966 were 96 and 70 nCi/m². Fallout from the Chinese weapons test (primarily short-lived barium-lanthanum–140) accounted for the large increase. Beryllium–7, an isotope continuously being produced in nature by cosmic interactions in the upper atmosphere, was a measurable component in environmental radioactivity. Deposition at each sampling location is presented in table 9 SRP contributions to the levels of radioactivity in foods were so low in 1966 as to be indistinguishable from past atmospheric weapons test fallout.

Algae and fish in Savannah River

Fish, predominantly bream, and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream from, adjacent to, and downstream from the Savannah River Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Beta-particle concentrations in algae and fish adjacent to and downstream from SRP indicate some minor contribution by SRP. Although measurably higher

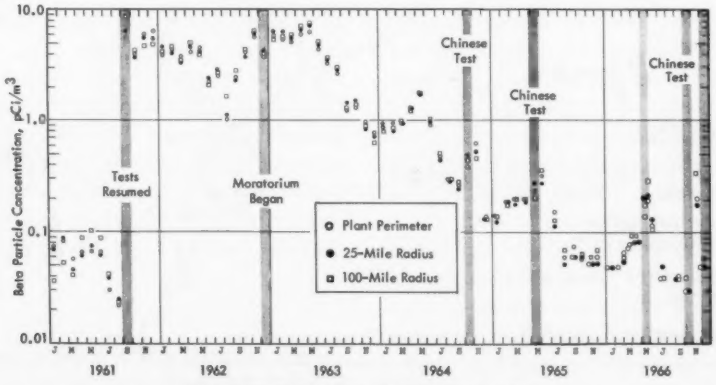

Figure 7. Influence of weapons tests

Table 8. Radioactivity in air, Savannah River Plant, July-December 1966

Filter analysis	Average concentration (pCi/m³)															
	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha particle emitters [a] (multiple by 10^{-3})																
Maximum	1.2	1.5	1.1	1.4	1.0	------	1.0	1.0	1.1	1.2	1.1	1.2	0.8	1.1	2.1	0.9	
Minimum	0.3	0.4	0.4	0.3	< .3	------	0.4	0.3	< 0.3	0.4	0.4	0.4	< .3	0.3	< 0.3	.3	
Average	.7	.7	.7	.7	.6	0.7	.6	.6	.6	.7	.6	.7	.5	.6	.9	.6	0.6
Nonvolatile beta-particle emitters [b]																	
Maximum	.33	.20	.22	.31	.22	------	.23	.22	.22	.21	.15	.21	.41	.24	.27	.16	
Minimum	.03	.03	.03	.03	.02	------	.03	.03	.02	.03	.02	.02	.02	.02	.03	.02	
Average	.10	.08	.09	.10	.08	.09	.08	.08	.08	.09	.08	.07	.09	.09	.10	.07	.08
Specific radionuclides (averages)	Composite sample						Composite sample										
Strontium-89,-90	0.005						0.008										
Cesium-137	.005						.004										
Cerium-141,-144	.033						.027										
Ruthenium-103, -106	.029						.037										
Zirconium-niobium-95	.005						.005										
Manganese-54	< .002						< .002										

[a] Sensitivity of analysis—3.0×10^{-4} pCi/m³; ICRP Maximum Permissible Concentration: 0.04 pCi/m³.
[b] Sensitivity of analysis—0.006 pCi/m³; ICRP Maximum Permissible Concentration: 100 pCi/m³.

Table 9. Total fallout deposited, Savannah River Plant, July–December 1966

Radionuclide	Deposition (nCi/m²)															
	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha [a]	2.82	2.43	5.02	2.55	2.93	3.17	1.70	3.13	3.32	2.01	3.17	6.02	2.90	4.86	2.55	2.55	3.20
Strontium-89	2.20	1.00	1.93	1.62	1.85	1.74	1.58	1.58	2.01	2.39	1.39	1.31	2.28	1.04	1.81	1.70	1.70
Strontium-90	0.54	0.58	0.58	0.54	0.58	0.62	0.58	0.62	0.46	0.58	0.77	0.58	0.69	0.85	0.54	0.54	0.62
Iodine-131	------	------	------	------	.42	.08	------	------	.39	------	------	------	------	------	.46	------	.08
Cesium-137	1.39	.96	1.20	.96	1.20	1.16	.73	.66	.62	.42	.54	.58	.50	.66	.62	.46	.58
Cerium-141, -144	2.86	1.78	4.09	3.05	2.78	2.90	2.24	.93	1.70	1.47	2.66	2.47	2.55	1.54	1.27	5.87	2.28
Ruthenium-103, -106	4.05	3.09	3.24	3.01	2.24	3.13	2.97	2.97	1.78	1.78	2.74	3.17	2.55	1.81	1.54	6.33	2.78
Barium-lanthanum-140	5.44	6.83	7.99	5.52	5.71	6.29	6.76	6.18	4.63	3.86	8.07	5.48	5.48	3.98	3.63	3.59	5.17
Zirconium-niobium-95	4.17	1.12	7.68	3.71	3.16	3.98	2.78	.77	1.62	1.54	6.87	4.36	3.86	1.47	1.24	15.63	4.01
Manganese-54	.08	------	.12	.08	------	.04	------	.04	.08	.12	.08	.12	.08	.08	.08	.04	.08
Beryllium-7	5.71	4.75	8.89	7.33	8.57	7.06	4.98	3.86	3.01	3.74	3.55	3.71	3.17	2.55	5.37	5.17	3.90

[a] Multiply by 10^{-3}.

than similar material collected at the control station 3-miles upstream from SRP, the slight increase is of no biological significance.

Specific radionuclide analyses were made on algae and fish collected from the Savannah River. Radiocesium and radiostrontium were found consistently in river algae; whereas cerium–141–144, chromium–51, zirconium-niobium–95, manganese–54, zinc–65, and cobalt–60 were detected less frequently. Also, radiostrontium (maximum, 12 pCi/g, wet weight) was detected in bone tissue of river fish, and radiocesium (maximum 7 pCi/g, wet weight) was detected in the flesh tissue. Radiozinc and phosphorous–32 were detected less frequently in these tissues. The maximum concentrations of phosphorous–32 detected in bone and flesh tissues of river fish were 430 pCi/g and 12 pCi/g, respectively.

Water monitoring

The plant site is drained by five streams which flow several miles through the reservation before reaching the river (figure 8). In

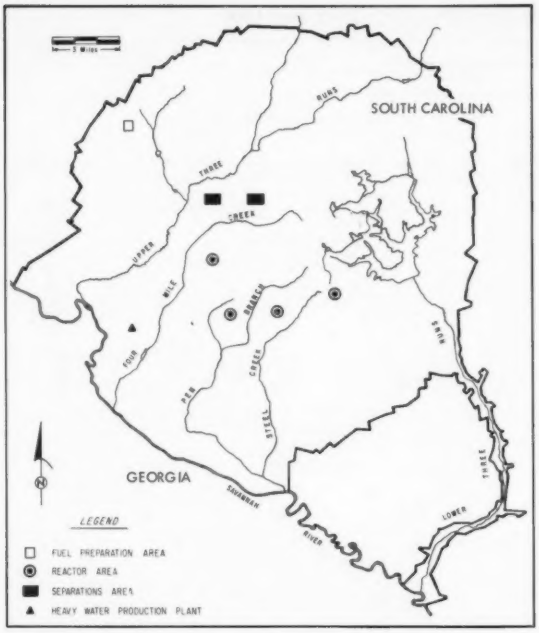

Figure 8. SRP production areas and effluent streams

January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the SRP. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Communities near SRP get domestic water from deep wells or surface streams. Public water supplies from 14 surounding towns were collected and analyzed in October. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.2 pCi/liter) and beta radioactivity (5 pCi/liter) were essentially the same as those observed before plant startup.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or absorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at nine other locations along a 25-mile radius route (not designated on figure 5). Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Radionuclides in grass samples were from weapons test fallout. Alpha-particle emitters averaged 0.1 pCi/g at the plant perimeter and 25-mile radius locations as compared to 0.2 pCi/g during the first half of 1966; gamma-ray emitters averaged 24 and 21 pCi/g, respectively, as compared to 51 and 38 pCi/g for the first half of 1966.

Milk

Milk was sampled at four dairies within a 25-mile radius of SRP, as shown in figure 5. Samples which were collected biweekly, were analyzed for tritium, radiocesium, and radioiodine. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during July–December 1966 are in table 10.

Average concentrations of three radionuclides in milk (31 pCi/liter for cesium–137, 20 pCi/liter for strontium–90, and less than 5 pCi/liter for iodine–131) were consistent with values reported by the U.S. Public Health Service for most sections of the United States during the second half of 1966. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis, which allows detection of concentrations of 3,000 pCi/liter (1 percent of the MPC for water).

Food

Forty-seven samples representing 4 food categories (fruit, grain, leafy vegetable, and poultry) were collected during the summer and fall of 1966 at 14 localities in the 6 counties surrounding SRP (not shown on figure 5). With the exception of grains, all foods were prepared for analysis in a manner similar to that used to prepare them for eating. Peelings, seeds, and other nonedible parts were removed.

Table 10. Radioactivity in milk from local dairies, Savannah River Plant, July–December 1966

Location of local dairies	Concentration (pCi/liter)											
	Tritium [a]			Strontium-90 [b c]		Iodine-131 [d]			Cesium-137 [e]			
	Maximum	Minimum	Average	July 1966	December 1966	Maximum	Minimum	Average	Maximum	Minimum	Average
Aiken	5,000	<3,000	<3,000	22	16	<5	<5	<5	59	<30	35
Allendale	<3,000	<3,000	<3,000	10	NS	<5	<5	<5	64	<30	51
North Augusta	5,000	<3,000	<3,000	29	18	<5	<5	<5	49	<30	<30
Waynesboro	4,600	<3,000	<3,000	22	24	<5	<5	<5	42	<30	<30
Major distributions [f]	3,800	<3,000	<3,000	23	18	<5	<5	<5	66	<30	42

[a] Sensitivity of analysis—3,000 pCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter.
[c] Strontium-90 determinations were made quarterly.
[d] Sensitivity of analysis—5 pCi/liter.
[e] Sensitivity of analysis—30 pCi/liter.
[f] Milk produced in local dairies, but sold by major distributors.
NS, no sample collected.

Wheat, containing the whole grains only, and oats, containing both grains and husks, were processed unwashed. Gamma-ray spectrometry was used to analyze samples for cerium–141–144, ruthenium–103–106, iodine–131, cesium–137, manganese–54, and zirconium-niobium–95. Radiostrontium and alpha radioactivity (uranium and plutonium) were determined by radiochemical analysis.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 5. Average concentrations of specific radionuclides found in river water during July–December 1966 are in table 11.

Table 11. Average concentration of radionuclides in Savannah River water, July–December 1966

Radionuclide	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at Highway 301
Tritium	600	1,000	11,600	1.2
Ruthenium-103, -106	3.2	<3.2	< 3.2	<0.10
Cerium-141, -144	2.5	<2.5	< 2.5	< .08
Cesium-134, -137	0.6	<0.6	3.3	.05
Neptunium-239	.9	< .9	4.6	.02
Barium-lanthanum-140	1.6	<1.6	< 1.6	< .02
Zirconium-niobium-95	.5	< .5	.6	.003
Chromium-51	4.3	<4.3	19.4	.003
Strontium-89	.3	< .3	1.0	
Iodine-131	.5	< .5	< .5	
Strontium-90	.01	.9	1.5	
Cobalt-60	1.4	<1.4	< 1.4	< .01
Zinc-65	1.1	<1.1	< 1.1	< .01
Manganese-54	.4	< .4	< .4	< .001

Cesium–137, strontium–89, strontium–90, chromium–51, tritium, and trace amounts of cerium–141, zirconium-niobium–95, and iodine–131, released mainly from reactor areas, were the radionuclides of SRP origin dectectable in river water at the downstream location. Average concentrations of all radionuclides found in river water during July–December 1966 were only small fractions of the permissible concentrations. The tritium concentrations in finished water collected from the Beaufort-Jasper Water Plant averaged 8,300 pCi/liter (0.8 percent of the MPC) during the 6-month report period.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy water moderator in the reactors. Chromium–51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). Tritium and chromium–51 are among the least dangerous of all radionuclides because neither concentrates in body tissues. The tritium and chromium–51 concentrations in river water averaged 1.2 and 0.003 percent of the MPC, respectively.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The July–December 1966 data (table 12) are characteristic of measurements observed at individual stations for the past several years.

Table 12. Environmental gamma radiation, Savannah River Plant, July–December 1966

	Exposure (mR/day)															
	Plant-perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Maximum	0.29	0.27	0.32	0.28	0.29	------	0.26	0.20	0.25	0.30	0.31	0.26	0.29	0.27	0.29	0.28	
Minimum	.24	.21	.18	.19	.19	------	.13	.15	.17	.21	.21	.14	.17	.12	.16	.17	
Average	.26	.24	.27	.24	.24	0.25	.21	.17	.22	.26	.24	.21	.24	.22	.24	.23	0.22

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July–December and calendar year 1965	August 1966
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SECTION V. TECHNICAL NOTES

Environmental Radioactivity in Woods Soil from Dover, New Jersey During 1964—1966

Samuel Helf [1]

In 1963 an extensive environmental radioactivity measurement program for gamma-emitting radionuclides was initiated on the U.S. Army Picatinny Arsenal military reservation and the surrounding region. These measurements were made primarily to provide a basis for distinguishing between radioactivity resulting from worldwide nuclear fallout and potential contamination from onsite radiological operations. The latter includes the operation of several multi-kilocurie sources of gamma radiation for radiation effects studies and both low- and high-level radiotracer experiments for research and development applications. Initially, samples assayed included grass, leaves, river and lake water, lake and stream mud, and precipitation. Results of these measurements are described in another report (*1*).

In 1964, this sampling program was expanded to include woods soil because it was observed that, on a unit weight basis, the quantity of radioactivity was considerably greater than in other types of environmental samples. This woods soil sampling program was continued on an approximately monthly basis through October of 1966 and these results are described here.

Experimental

Samples were collected from a wooded hillside at the inlet end of Lake Picatinny located approximately in the center of the military reservation. Trees on this site are primarily deciduous, consisting mainly of oak trees common to the general area. Samples were taken from the top 2 inches of soil after the surface litter was brushed away. All stones, twigs, leaves and other extraneous matter were carefully removed and the resulting soil was dried to constant weight at 110° C. The 1964 samples were counted in waxed cardboard containers (Disposo Cups) having a volume of 150 cc, the average weight of soil being approximately 40 grams. In 1965 and 1966 samples were counted as 1.0 liter volumes in a Marinelli-type polyethylene beaker. The average weight of soil here was 288 grams.

Radioassay was performed by gamma-ray spectrometry. Resolution of individual radionuclides was accomplished with the aid of an IBM–7090 electronic computer using either simultaneous equations (*2*) or weighted linear least squares (*3*) techniques. The scintillation detector consisted of a 4- by 4-inch sodium iodide (thallium-activated) crystal coupled to a 3-inch window multiplier phototube. The detector assembly was housed in an Oak Ridge National Laboratory type "pickle-barrel" lead shield consisting of 3 inches of lead all around. The signal from the detector was fed into a 400-channel pulse-height analyzer. Counts were accumulated in 200 channels of the memory with the analyzer calibrated for 10.0 keV per channel. Thus the energy range scanned was from 0 to 2 MeV. Each sample was counted for at least 100 minutes .

[1] Mr. Helf is a research radiochemist with the Feltman Research Laboratories, U.S. Army, Picatinny Arsenal, Dover, N.J.

The library of standards used in the computer programs was made from reference solutions of known specific radioactivity. These standards were counted as aqueous solutions under the same geometry conditions as the unknowns.

Results

Five nuclear fallout gamma-emitters were determined in each soil sample. These nuclides and their respective half-lives are manganese–54 (314 days), ruthenium–106 (1.0 years), antimony–125 (2.7 years), cesium–137 (30 years), and cerium–144 (285 days). The origin of these radionuclides is presumed to be from "aged" nuclear fallout resulting from atmospheric tests conducted by the United States and Soviet Russia through the fall of 1962. Zirconium–95 (65 days) was observed in the early 1964 soil collections in concentrations from about 1 to 10 pCi/g but was no longer detectable after June of that year. This nuclide was again observed at barely detectable levels (about 1 pCi/g) in June 1966, and in the subsequent 1966 collections. The reappearance of zirconium–95 is presumed to have originated from recent Chinese nuclear experiments on the Asian mainland.

Naturally-occurring potassium–40 was also measured. No artificial radioactivity whose origin can be attributed to local sources was detectable.

The gamma-ray spectra of three soil samples collected at 1 year intervals from the Picatinny Arsenal location are shown in figure 1. Gross counts normalized to unit time and weight, are plotted logarithmically on the ordinate. The abscissa is given in channels corresponding to 10 keV of gamma-ray energy per channel. Taking into account differences in relative concentrations, the shapes of all three spectra are similar. It is therefore concluded that the composition of the spectra remained constant during the 2-year period, differing only in the concentrations of the individual species.

The concentrations in the woods soil of each of the five long-lived artificial radionuclides, in pCi/g, are shown graphically in figure 2, from February 1964, to October 1966. No significant differences are observed among the concentration profiles of the five elements. Thus, there appears to be no important selective uptake or retention of any one radionuclide over another in this particular type of soil.

The average annual concentration for each

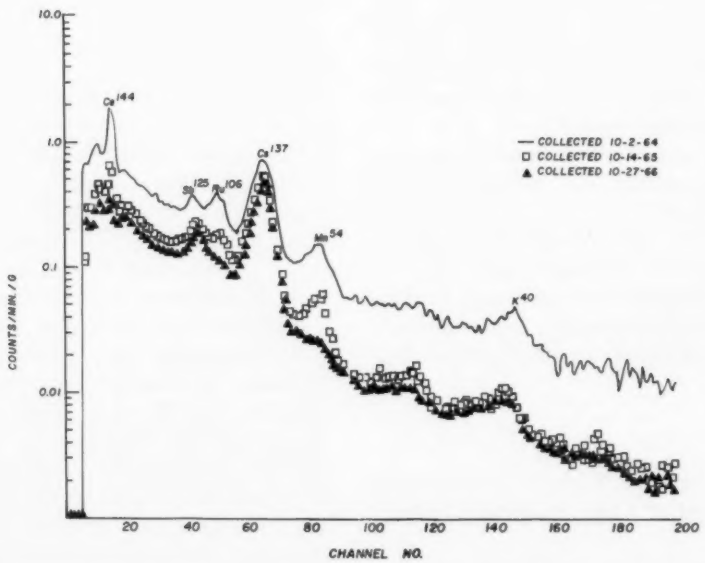

Figure 1. Gamma-ray spectra of three woods soil samples collected from the same Picatinny Arsenal location at 1-year intervals

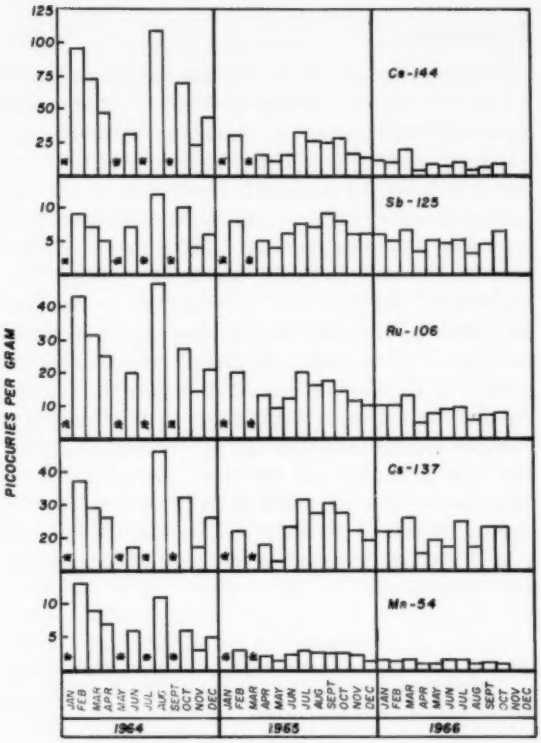

Figure 2. Concentrations of fallout radionuclides in Picatinny Arsenal woods soil, as recorded monthly, 1964–1966
***Indicates that no sample was collected for that month**

artificial radionuclide, during this period, is given in table 1. Also included are the average annual measured potassium–40 concentrations.

Total precipitation on a monthly basis during this collection period is shown in figure 3. There is no obvious correlation observed between these precipitation levels and the monthly radionuclide concentrations.

Accuracy of measurements

It is difficult to estimate an absolute accuracy of radionuclide analysis for environmental

Table 1. Average annual radionuclide concentrations in Picatinny Arsenal woods soil

Radionuclide	Concentration (pCi/g)		
	1964	1965	1966
Cerium-144	60.5	20.7	8.4
Antimony-125	6.0	6.5	5.0
Ruthenium-106	28.4	14.1	8.0
Cesium-137	28.9	23.2	21.0
Manganese-54	7.4	2.3	1.3
Potassium-40	10.9	7.2	7.6

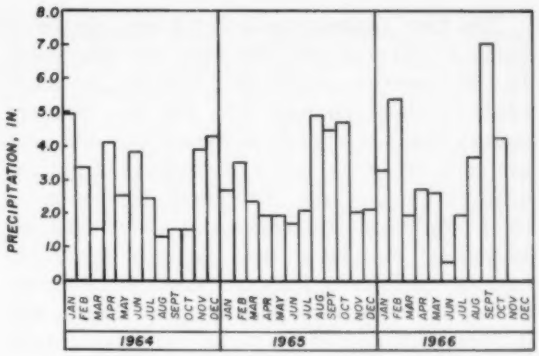

Figure 3. Total precipitation recorded on a monthly basis at Picatinny Arsenal during soil sampling period

samples which have been radioassayed by gamma-ray spectrometry. This is primarily because the qualitative radionuclide composition of an environmental sample is assumed. As a result, statistical treatments of data obtained by electronic computer methods give only measures of agreement or "goodness of fit" between the measured spectra and the fixed library of reference standards.

Cambray and co-workers (*4*) have experimentally determined "uncertainty in the analysis" which they designate as σ_a for gamma-ray spectrometric determinations on environmental rainwater and airborne dust samples. Except when near the limits of detection the following nominal values of σ_a are claimed: cerium–144, 8 percent; antimony–125, 20 percent; ruthenium–106, 15 percent; cesium–137, 6 percent; zirconium–95, 6 percent; manganese–54, 7 percent. These reported σ_a values, however, are measures of analytical precision and do not necessarily denote the true error of the determination for a particular radionuclide.

The accuracy of the soil radioactivity measurements described in this report was estimated by comparing the gamma-ray spectrum of a simulated sample of the same composition as determined for a field sample. The simulated sample was made up as 1.0 liter of acidified distilled water and contained the standard reference radionuclides in concentrations to correspond with those determined by computer assay of the November 1965 field sample. Since the actual soil sample weighed 253 g the only known difference between the two samples was that of density, *i.e.*, 0.253 *vs.* 1.0.

The two gamma-ray spectra are shown in figure 4. Some slight differences are observable. In the spectrum of the field sample, the small peak at about channel 170 and the two low energy peaks to the left of the cerium–144 peak are most likely due to decay products of natural uranium or thorium. The small differences in the Compton-scatter regions at about channels 40 and 100 may be at least partially due to the density variations between the two samples. However, in the photopeak areas of the six designated gamma-ray emitters comprising both the soil and simulated samples, the spectra are strikingly similar. The original assumption as to the radionuclide composition of the soil is therefore sound with regard to detectable species and errors in the analysis due to a departure from this assumption are negligible.

The true errors in these measured radionuclide concentrations can therefore be assessed in terms of experimental and analytical factors which are either known or can be reliably estimated. These are the accuracy of the reference calibration standards, computer resolution errors, counting statistics, and sampling errors, in that order of importance. On this basis, the artificial radionuclide concentrations as given in this report, are estimated to be accurate to ± 10 percent for ruthenium–106, ± 6 percent for cesium–137, and ± 15 percent for cerium–144, antimony–125, and manganese–54.

Discussion

During the course of this soil radioassay program, it was found that the levels of artificial radioactivity found in Picatinny Arsenal soil samples were considerably higher than in some random samples collected from outside of the military reservation. It was suspected that this was due to the particular nature and composition of the soil in the arbitrarily selected Arsenal site. To test this hypothesis, on October 14, 1965, in addition to the usual sample, three additional soils were obtained from locations within a 15-mile radius of Picatinny Arsenal. Again, each sample came from a primarily deciduous woods area and the soil was taken from the top 2 inches of surface. In addition to radioassay, the ash content of each sample was also determined. These results are shown in table 2 and are presented in order of increasing ash content.

Table 2. Radioassay of four different northern New Jersey woods soil samples collected on October 14, 1965

Location	Ash content (percent)	Concentration (pCi/g)				
		^{144}Ce	^{125}Sb	^{106}Ru	^{137}Cs	^{54}Mn
Picatinny Arsenal	22.0	27.3	7.8	14.3	27.1	2.7
Morristown	80.4	6.2	2.4	4.5	9.4	1.1
Shongum Lake	84.4	2.6	1.3	2.0	3.1	0.6
Newton	92.3	2.6	1.1	1.6	1.5	0.6

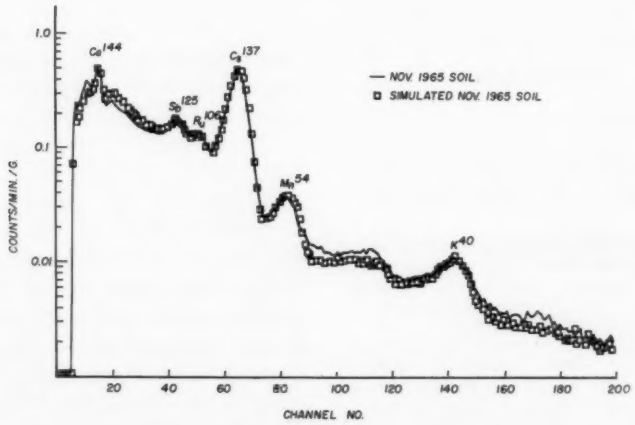

Figure 4. Comparison of gamma-ray spectra of simulated and field soil samples

The measured radionuclide concentrations are, in general, inversely related to the ash content, or conversely, the higher the content of organic matter in the soil, the higher is the concentration of each artificial radionuclide. The Picatinny Arsenal sample, which has a considerably higher organic content contains the highest concentration of these radionuclides.

The higher concentrations of fallout radionuclides in organically-rich soils are attributed partially to the original presence of the radioactivity in the vegetation from which the organic matter is derived. Another factor, perhaps of equal or greater importance, is a high retention capacity for radionuclides which settle directly on this type of soil. Organically-rich soils are known to have a higher exchange capacity for most cations than sandy soils (*5*). Once adsorbed in the complex organic structure, the radionuclides can be expected to become relatively fixed and not as easily washed out by rainfall. This is supported by experiments which have shown that the uptake of fallout radionuclides by plants was much less from organically-rich soils than from sandy soils (*6*).

The unusually high organic content of the Picatinny Arsenal woods soil is related to the general geology of the immediate region. The site is characterized by many rock outcroppings which extend over large areas dating back to the most recent glacial activity. As a result, overburden throughout the region is either non-existent or very thin and there is little or no soil. Woods soil in this locality is therefore composed mostly of organic matter derived from fallen vegetation.

There is little published information on soil radionuclide measurements from other parts of the United States for this period, which would allow for a direct comparison with the data reported here. Wykes (*7*) has reported cesium–137 concentrations in soil collected in the dairyland region of Elk River, Minnesota. Average annual values for 1964 and 1965 are given as 1.4 and 1.5 pCi/g, respectively, and the soil samples are characterized as essentially sandy in composition. These values are similar to those for Newton and Shongum Lake, New Jersey. In contrast, the average annual values for cesium–137 in Picatinny Arsenal woods soil (table 1) were 28.9 and 23.2 pCi/g for these 2 years.

Acknowledgement

The author is grateful to C. M. Starrett, R. I. Isakower and P. J. Kemmey for their assistance with the computer programs for the radionuclide analyses.

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Cesium–137 Burdens of Some Cincinnati Residents, July 1964–March 1967

H. E. Kolde [1]

The whole-body counter of the National Center for Radiological Health at Cincinnati, Ohio was employed to monitor 190 residents of the Cincinnati metropolitan area during the period July 1964 through March 1967. The cesium–137 values obtained have been compiled for this report to provide current data for comparison with other populations exposed to this radionuclide in their environment.

The majority of the subjects were local residents for at least the past 5 years and consisted of Public Health Service personnel, employees of an Atomic Energy Commission contractor, and dietitians from local hospitals. They ranged in age from 16 to 57 years but most of them were 25 to 40 years old. Data for individuals that showed burdens of radionuclides other than cesium–137 and potassium–40 or with frequent occupational exposure to cesium–137 were excluded since they were from a different "population." Approximately 30 of the subjects were monitored on three or more occasions during the period. Results for any person monitored more than once in any quarter were averaged and entered as a single observation.

The whole-body counter consists basically of an 8- by 4-inch NaI (T1) detector with a NaI light pipe, a multichannel analyzer, and an 8- by 12-foot steel room with a 5-inch wall thickness (*1*). Subject geometry and detector location conform to the tilted chair configuration defined by the International Atomic Energy Agency (IAEA) (*2*). The system has been standardized for potassium–40 measurements by the *in vivo* technique of administering potassium–42 intravenously to 10 persons ranging in weight from 60 to 129 kg. The cesium–137 calibrations were performed with phantom humans constructed of various parcels of sugar loaded with portions of an absolutely standardized solution. The adequacy of the phantom designs was determined by loading them with potassium–42 or potassium–40 and comparing the results to those derived *in vivo*. The potassium–42 experiment and work with the phantoms loaded with cesium–137 have shown that the counting efficiency of this system decreased linearly with increasing body weight. The interference factors for subtracting potassium–40 contributions from the cesium–137 portion of the human gamma-ray spectrum were determined by the potassium–42 experiment.

The overall random error for individual cesium–137 observations varied commonly from ±7 to ±11 percent at the 95-percent confidence level for 1964 observations to ±10 to ±35 percent for males and ±20 to ±60 percent for females in early 1967. Precision of cesium–137 measurement is calculated on the basis of errors propagated by the subject and background counting rates, potassium–40 spectral interference, and the uncertainty in fitting the cesium–137 efficiency curve. Subject counting duration is 30 minutes. The minimum detectable radioactivity is 0.5 nCi at the 95-percent confidence level for a 30-minute measurement of a 70-kg individual with a potassium content of 154 grams.

Table 1 presents the results of the cesium–137 measurements averaged on a quarterly basis separately for the two sexes. It should be noted that these measurements were obtained incidental to performance of other studies, and information is unfortunately sparse during several intervals of experimental usage of the counter. Downward trends in cesium–137 burdens, however, are apparent, as anticipated from the suspension of nuclear testing in the atmosphere by the United States, Russia, and Great Britain. The levels in males in the first quarter of 1967 are approximately one-third of those observed in the third quarter of 1964. The burdens in females declined to approximately 25 percent of original values. The dis-

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Table 1. Quarterly average cesium-137 contents of metropolitan Cincinnati residents [1] July 1964–March 1967

Quarter and year	Individuals per quarter [a]	Average weight (kg)	Average potassium concentration (g/kg)	Average cesium-137 concentration		Average body burden (nCi)
				(pCi/kg)	(pCi/g K)	
Male						
3rd/64	12	77.4	2.1	[b] 250± 95	120	19
4th/64	14	78.1	2.2	240±160	110	19
1st/65	2	84.9	2.2	240± 60	100	21
2nd/65	8	83.4	2.2	200± 90	90	17
3rd/65	7	83.4	2.0	190± 50	90	16
4th/65	30	79.8	2.0	170± 75	85	13
1st/66	57	79.9	2.0	140± 60	70	11
2nd/66	60	77.5	2.0	120± 70	60	9
3rd/66	14	78.6	2.1	110± 60	60	9
4th/66	17	77.0	2.1	95± 55	45	7
1st/67	13	81.5	2.0	85± 35	45	7
Female						
3rd/64	9	65.1	1.7	170± 95	100	11
4th/64	10	62.6	1.6	140± 80	85	9
1st/65	5	58.7	1.8	140± 50	80	8
2nd/65	4	57.3	1.8	120± 45	70	7
3rd/65	6	61.3	1.6	110± 75	75	7
4th/65	12	61.1	1.7	80± 60	45	5
1st/66	16	62.7	1.7	80± 65	45	5
2nd/66	16	62.2	1.6	60± 55	40	4
3rd/66	13	64.4	1.6	50± 40	30	3
4th/66	10	66.4	1.6	35± 45	20	2
1st/67	14	65.2	1.6	40± 35	25	3

[a] Results were averaged for each individual counted more than once per quarter and denoted as one observation in that quarter.
[b] Variation of individual results at 2 standard deviations.

appearance of cesium–137 radioactivity in whole-body spectra was noted for the first time during this monitoring in the measurement of two female subjects during December 1966.

To demonstrate the decrease in cesium–137 content of a single individual, results were compiled for the subject most frequently monitored (table 2). The subject was a male in good health, 35 to 37 years of age, who varied in weight by less than ±3 percent. His average potassium concentration was 2.1 g/kg and his dietary habits were relatively constant, although he reduced his milk consumption from slightly more than 1 quart per day to approximately 1 pint per day in June 1966. Cesium–137 burdens in this case decreased by a factor of 3.4.

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Table 2. Quarterly average cesium-137 contents of one male adult, July 1964–March 1967

Quarter and year	Observations	Average weight (kg)	Average potassium concentration (g/kg)	Average concentration		Average burden (nCi)	Average cesium-137 analytical measurement error (percent)
				(pCi/kg)	(pCi/g K)		
3rd/64	2	71.7	2.1	[a] 335±30	160	24	[b] ± 7
4th/64	2	74.1	2.1	300±35	140	22	± 7
1st/65	2	74.5	2.2	285±35	120	21	± 7
2nd/65	5	72.5	2.3	260±20	110	19	± 7
3rd/65	2	71.2	2.0	195± 0	95	14	± 9
4th/65	3	72.0	2.0	160±30	75	12	±10
1st/66	6	72.5	2.1	145±30	65	10	±10
2nd/66	7	73.4	2.2	145±25	65	10	±11
3rd/66	6	73.4	2.1	120± 5	55	9	±12
4th/66	9	73.2	2.1	100±25	45	8	±15
1st/67	8	74.5	2.0	95±25	40	7	±14

[a] Variation of individual results at 2 standard deviations.
[b] Error given at 2 standard deviations.

Plutonium Concentrations in Ground Level Air and Changes in Plutonium-238 To Plutonium-239 Ratios

B. Shleien and *P.J. Magno* [1]

Information on airborne plutonium isotopes is of interest in evaluating the potential health hazard of these material and in investigating the transport processes involved. A unique injection of plutonium–238 into the atmosphere took place in April 1964 when 17 kilocuries of this isotope contained in a SNAP–9A power source burned up south of the equator off the coast of Africa (*1*). Analysis of ground level airborne particulate samples for plutonium isotopes has been performed at the Northeastern Radiological Health Laboratory since May 1965. Airborne concentrations for 1965 have been presented elsewhere (*2*). Data for January 1966 to February 1967 are presented in this paper.

Monthly composite particulate samples representing 12,000 m^3 of air are collected on 8- by 10-inch membrane filters (pore size 0.8μ) at a height of one meter above the ground. The samples are wet ashed with a mixture of nitric and perchloric acids. Plutonium–236 tracer is added, the plutonium reduced to the +3 state and coprecipitated with lanthanum fluoride. The fluoride precipitate is then converted to hydroxide, dissolved in 7.2 *M* nitric acid and the plutonium oxidized to the +4 state.

Plutonium is sorbed from the solution on an anion exchange resin in the nitrate form. The resin is washed with additional 7.2 *M* nitric acid, and then with 9 *M* hydrochloric acid. The plutonium is eluted from the resin with a mixture of 0.36 *M* hydrochloric acid and 0.01 *M* hydrofluoric acid, and finally electroplated onto a stainless-steel planchet from a sulfuric acid-ammonium sulfate electrolyte.

Samples are usually counted in an alpha-particle spectrometer for at least 1,000 minutes with a silicon surface barrier detector of 450 mm^2 surface area. Counting efficiency is approximately 31 percent. Chemical yield is determined by the recovery of the plutonium–236 tracer.

Concentrations of plutonium–239 [2] and plutonium–238 in ground level airborne particulates at Winchester, Mass. for the period of January 1966 to February 1967 are presented in table 1. The mean concentration for plutonium–239 was 0.068 fCi/m^3 and the mean concentration for plutonium–238 was 0.006 fCi/m^3. The mean concentration of plutonium–239 decreased by one-half from the mean previously reported (May 1965 to April 1966) (*2*), while the mean plutonium–238 concentration remained relatively constant. A change in the plutonium–238 to plutonium–239 ratio becomes fairly evident in mid-1966. The change in the ratio indicates a new source of plutonium–238 than that which was previously present. A probable conclusion is that plutonium–238 from the SNAP–9A burn-up has reached ground level in the Northern Hemisphere.

The expected spring rise in plutonium–239 concentration was evident after January and reached a maximum in May 1966. The magnitude of measurement errors in plutonium–238 analysis does not permit firm conclusions concerning a spring rise for this nuclide, although a general increase in plutonium–238 concentration appears to have been present during the spring months.

Using a plutonium–238 to plutonium–239 ratio of 0.04 for weapons debris, an estimate of plutonium–238 from SNAP–9A can be made and is presented in table 1. The ratio of plutonium–238 to plutonium–239 from September

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[2] The energies of the alpha particles from plutonium–239 and plutonium–240 are not sufficiently different to be separated by the alpha-particle spectrometry method employed. Therefore, when plutonium–239 is referred to in this report, it is meant to represent the sum of the activities of plutonium–239 and plutonium–240.

1966 on appears to have been statistically similar. Although errors are large, an increase in SNAP–9A plutonium–238 is indicated. A similar increase has been reported in Italy (*3*). The estimates for plutonium–238 because of the SNAP–9A burn-up agree with those estimated by the Health and Safety Laboratory (HASL) (*4*). The data presented above appears to be indicative of an intrusion of plutonium–238 into ground-level air in the Northern Hemisphere from the burn-up of SNAP–9A.

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Table 1. Plutonium-239 and plutonium-238 in airborne particulates at ground level at Winchester, Mass., 1966-1967

Month	Radionuclide concentration ($fCi/m^3 \pm E$) [a]		Ratio $\pm E$ [a] ^{238}Pu: ^{239}Pu	Estimated [b] ^{238}Pu from SNAP-9A (fCi/m^3)
	Plutonium-239	Plutonium-238		
1966				
January	0.047 ±0.010	0.001 ±0.002	0.02 ±0.04	[c]
February	0.071 ±0.010	0.005 ±0.003	0.07 ±0.04	0.002 ±0.003
March	0.089 ±0.012	0.003 ±0.002	0.02 ±0.02	[c]
April	0.131 ±0.016	0.005 ±0.002	0.04 ±0.02	0.000 ±0.003
May	0.207 ±0.020	0.012 ±0.004	0.05 ±0.02	0.004 ±0.006
June	0.130 ±0.014	0.008 ±0.003	0.06 ±0.02	0.003 ±0.004
July	0.073 ±0.010	0.003 ±0.003	0.04 ±0.04	0.000 ±0.003
August	0.050 ±0.006	0.005 ±0.002	0.10 ±0.04	0.003 ±0.002
September	0.035 ±0.003	0.004 ±0.003	0.11 ±0.09	0.003 ±0.003
October	0.020 ±0.006	0.005 ±0.003	0.25 ±0.16	0.004 ±0.003
November	0.025 ±0.006	0.011 ±0.004	0.44 ±0.19	0.010 ±0.003
December	0.018 ±0.005	0.003 ±0.003	0.17 ±0.17	0.002 ±0.003
1967				
January	0.022 ±0.006	0.005 ±0.003	0.23 ±0.15	0.004 ±0.003
February	0.027 ±0.006	0.007 ±0.003	0.26 ±0.12	0.006 ±0.003

[a] Error at 95-percent confidence level due to radiochemical and counting errors.
[b] Based on mean plutonium-238 to plutonium-239 ratio May 1965 to July 1966 of 0.040 ±0.02.
[c] The estimated plutonium-238 from SNAP-9A for these months, based on a mean plutonium-238 to plutonium-239 ratio of 0.04 ±0.02 result in negative value which should be interpreted as 0.00 fCi/m^3 from SNAP-9A. The actual results obtained are: January 1966, 0.001 ±0.002 fCi/m^3; March 1966, 0.001 ±0.003 fCi/m^3.

Reported Nuclear Detonations, August 1967

During August 1967, three U.S. underground nuclear tests of low yield (less than 20 kilotons TNT equivalent) were announced by the Atomic Energy Commission. These tests occurred on August 10, August 18, and August 31 at the Nevada Test Site.

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A PROPOSED RADIOACTIVITY CONCENTRATION GUIDE FOR SHELLFISH. *C. L. Weaver. Radiological Health Data and Reports, Vol. 8, September 1967, pp. 491–494.*

The recommendations of the International Commission on Radiological Protection (ICRP), the National Committee on Radiation Protection (NRCP), and the Federal Radiation Council (FRC) have been applied in deriving proposed guides for radioactivity in shellfish. FRC Report No. 1 presents basic exposure criteria, FRC Report No. 2 presents intake guides for strontium–89, strontium–90, iodine–131, and radium–226, and NCRP and ICRP provide data on the maximum permissible concentrations of radionuclides in water. The proposed guide was assembled by the National Center for Radiological Health in collaboration with the Water Supply and Sea Resources Program of the National Center for Urban and Industrial Health, Public Health Service.

KEY WORDS: aquatic food chains, intake guides, iodine–131, radioactive wastes, radium–226, shellfish, strontium–89, strontium–90.

RADIOACTIVITY IN THE MEXICAN ENVIRONMENT. *R. M. Nulman* and *M. V. Barete. Radiological Health Data and Reports, Vol. 8, September 1967, pp. 495–501.*

The Comisión Nacional de Energía Nuclear in Mexico operates surveillance networks monitoring radioactivity in airborne particulates, particulates in fallout and precipitation, drinking water, milk, food, and sea water. Methods of analysis and the resultant data for 1965 and 1966 are presented. This surveillance program was instituted to provide a general picture of the radioactivity levels in the Mexican environment, protection for the Mexican people from overdoses of radiation, and information for the handling of legal claims that may arise against the Nuclear Center of Mexico (now under construction).

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